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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: D.12.1

United Kingdom

THE ROLE OF HEAVY CHEMICALS IN INDUSTRIAL DEVELOPMENT

By F.G. LAMONT, M.Sc.

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AGENDA ITEM D 12.1

THE ROLE OF HEAVY CHEMICALS IN INDUSTRIAL DEVELOPMENT

F. G. LAMONT M.Sc.

1. The spectacular growth of the heavy chemical industry since 1945 in the highly industrialised countries has naturally encouraged the inclinations of the developing nations to accord this field a major place in their programmes of industrial development. In some cases this policy is justified but before assuming that this is always so it is necessary to consider the nature, functions and fundamental economics of the industry and hence the role it should play in the industrial development of the less well-developed areas.

2. "Heavy" chemicals are difficult to define exactly in succinct terms but broadly they may be described as those chemicals produced in a tonnage sufficiently large to permit the development of highly sophisticated chemical processes and the design of specialized plants for each individual process (or at most one or two closely similar processes in campaign working.) It is not necessary to dilate on the striking growth of the sciences of chemical engineering and process technology directed specifically towards this end but it must be emphasised that the universal characteristic of modern heavy chemical industry is the high degree of "knowhow" or more euphoniously "process technology" and specialisation peculiar to each and every such process.

3. It must also be recognised at the outset that the heavy chemical industry rarely serves the public directly but that most of its products form the raw materials or essential auxiliaries of other manufacturing industries. Indeed almost all industries are dependent upon them. In countries such as Australia it is customary to refer to agriculture, grazing etc., as "primary", and manufacturing as "secondary" industries. In this concept it would not be inappropriate to describe the heavy chemical industry (with others) as "tertiary" industry. These terms refer to considerations of timing or evolution rather than of ultimate importance. It is obvious that in general it would be unwise to embark upon a programme of heavy chemical manufacture until the consumming industries were sufficiently developed to support units of economic size.

4. Nevertheless, since heavy chemicals are required either as raw material or essential auxiliaries by almost every manufacturing industry the general progress of industrial development results in an every increasing and sometimes alarming demand for these chemicals and there is a natural desire to see them produced locally at as early a stage as possible. This can be misleading.

5. The discrepancy in the standards of living between the less and the most fully developed areas does not necessarily call for immediate industrial development. Countries with surpluses of food or other "primary" products and raw materials have achieved quite a high standard of living by developing exports of these in exchange for manufactured goods. In considering the less well developed areas it is natural to think of the newer Afro-Asian nations but it is not so long since Canada, Australia and South Africa merited this description and parts of them still do so. It is well to remember that their development was founded, and their present prosperity still largely depends on, primary industry. The same would seem to apply to South America also but of this the author has no first hand knowledge.

6. Conversely, countries without such surpluses but with adequate supplies of the requisite raw materials and power may justify chemical manufacture at an earlier stage. The role of the chemical industry, its pattern and impact must depend on the peculiar circumstances of the area in question to a greater extent than is perhaps usually realised.

7. Generally, however, industry follows hard on the heels of primary production and sooner or later the stage is reached when (heavy) chemical manufacture warrants consideration. The potential saving on imports is attractive if not indeed, vital, but at once the high capital cost of modern chemical plants proves a most serious obstacle. Development generally, but particularly industrial development requires massive capital investment and as the availability of capital whether from internal savings or external aid (both ultimately arising from voluntary saving or taxation of individuals) is inevitably limited development must be keenly selective particularly in the early stages of industrialisation, and in this the chemical industry must compete with others. It is also not sufficiently realised that the technical resources and manpower available frequently impose an even more severe limitation. This is the justification for the considerable degree of planning which is accepted publicly and certainly desirable privately in developing countries, but there is insufficient unanimity on the criteria to be adopted and the limitations of the above factors. There are few countries indeed in which the various "plans" have been fully completed within the stated period and have fully achieved the postulated results.

8. National authorities inevitably tend to be concerned primarily with balance of payment problems and to plan development mainly on this basis. The private sector tends rather to make its judgements on purely economic conditions. The disposal or utilisation of profits is a matter of policy both public and private, but the making of the profit (in this context the savings as compared with the previous situation) provides the means both of raising the standard of living through distribution of purchasing power and of generating further capital for future expansion. Whatever the policy clearly profitability is the best "rough and ready" yardstick in deciding what will contribute most to the tempo of development and, although compromise may later have to be made, it should be used as the first criterion in selecting both fields of development and individual projects. It is against this background that the role of heavy chemicals must be determined.

9. Obviously any planning whether on the national or individual scale must start with an assessment of the area's growing needs against the evolving pattern of its general development. This presupposes some decisions regarding priorities for such development and emphasises the "tertiary" role of the chemical industry. At once the question of timing or in popular parlance the "minimum economic size" arises but, although figures are often glibly quoted for particular processes, this concept is by no means as simple as generally supposed. It will be considered more fully later.

10. The next consideration is usually the availability of raw materials. The full range of these for the heavy chemical industry is very large but the main bulk comprises a relatively few items such as air, water, salt, lime, sulphur, phosphates carbon, and especially hydrocarbons. Rarely are all of these conveniently available. Energy, either as fuel or electricity, might almost be classed as a raw material also, so great is the dependence of many of the more important processes upon its availability and cost.

11. The basic processes of the chemical industry start from these raw materials yielding products sometimes referred to as "primaries" and serving generally as the starting point for further processes. Because of this a high degree of inter-locking is inevitable in the heavy chemical industry if economic operation is to be achieved and wasteful transport of intermediates avoided.

12. This inter-locking has been demonstrated on innumerable occasions by elaborate charts and it is not proposed to repeat them here as they are readily accessible and no doubt familiar to the delegates but it may be useful to consider briefly the major sectors of the heavy chemical industry in some such order as they might merit attention in a developing country.

13. One chemical process arises naturally, namely fermentation. Many countries have large resources of saccharosic material from which ethanol and other fermentation products can be produced cheaply and it would seem that over the last few decades an opportunity to exploit these may have been missed. The development of petrochemical processes is putting ethanol and other fermentations out of court in the highly industrialised areas but in view of the relatively low capitalisation and given sufficiently cheap raw material ethanol, butanol, acetone, acetic and citric acids and even possibly glycerine may still be worth consideration by fermentation routes, particularly if oil is not available indigenously. More complex products can be produced but the separation and recovery proves extremely difficult. The advent of new techniques might produce spectacular results.

14. Probably the first heavy chemicals required will be fertilisers and the relative importance of nitrogen, phosporous and potash is under discussion in other sections of the conference. These products are produced very efficiently on a very large scale in the advanced countries and it will require a large local demand and/or favourable circumstances to permit competitive manufacture but some premium may be considered justifiable to save foreign exchange. Nitrogen in the form of synthetic ammonia is generally the easiest to justify and for the traditional (and still generally preferred) product ammonium sulphate, anhydrite or gypsum

can be used rather than sulphuric acid which usually involves imports of sulphur. In certain countries work on the beneficiation of gypsum/anhydrite might be rewarding. The newer ammonium nitrate based products are attracting much attention. The newer processes for synthesis gas, based on naptha etc., have probably reduced the minimum economic size of plant as well as avoiding dependence on the all too scarce supplies of metallurgical coke.

15. Phosphate fertilisers pose a more difficult problem since in general import of rock phosphate and sulphur are involved. Only in very rare circumstances can production via elemental phosphorous be justified. Potash products are almost inevitably tied to the source of the mineral.

16. Consideration of fertilisers naturally leads on to acids. Sulphuric plants are now available virtually as package units where required but the availability of synthetic ammonia with possibly methanol as a side-line opens the way to nitric acid, and hence explosives, organic nitrations etc., as well as aminations etc.,

17. Explosives are a small but highly specialised field. It is easy to produce explosive compositions, as the bones of many men testify but the production of cheap safe efficient and reliable products involves a very special technology to which much research has been devoted. The recent trend towards crude on-site mixtures of ammonium nitrate (which still require to be initiated and boosted by sophisticated explosives) appears to be reversing. (1)

18. One product which because of its high transport cost can frequently be manufactured on relatively small scale is chlorine but only for such essential applications as public hygiene, water purification etc., For general industrial use, the woodpulp industry and particularly the plastics field and more complex chlorinated products, large units, say 20,000 tons and upwards, and cheap salt and power are essential.

19. Production of chlorine yields a useful bonus of caustic soda and indeed the demand for this usually surpasses that for chlorine until a very high level of industrialised development is achieved. This focuses attention on the soda ash process and caustic therefrom. Unfortunately the ammonia -soda process demands a very high degree of technical skill and large units; outputs of 200 tons per day being regarded as quite small. It is also all too often difficult to find satisfactory supplies of salt, lime and make-up ammonia as well as fuel within reach. The so called combined process obviates the lime difficulty but requires large supplies of ammonia and an outlet for the ammonium chloride which is separated. It is by no means as well established as the orthodox process.

(1) Damon G.H., Low-Cost Blasting Agents
J.Mines, Metals & Fuels. Special Issue
(1962) P.305

20. The availability of these fundamental chemicals opens the way to consideration of a great multitude of possible manufactures. On the inorganic side these are mainly salts of varying complexity with perhaps special mention of silicates and inorganic pigments. All of these involve specialised processes and it is impossible to generalise as to their practicability in newly developing areas. Opportunities may arise however, not merely of supplying local demand but of up-grading or semi-processing raw materials formerly exported in the crude state.

21. On the organic side the proliferation is even greater. Till recently the organic raw materials were largely derived from coal with the addition of acetylene, synthetic methanol, the simpler parrafin fractions and natural substances such as cellulose, rubber, oils and wares etc., The possible sulphonations, nitrations, chlorinations, aminations, oxidations, reductions hydroxylations etc., of these and all their permutations and combinations filled the technical literature as well as the warehouses. These units processes, if the raw materials and reagents are available can often be economic on a relatively small scale.

22. Stemming from the oil industry and influenced by its most modern technology, the new field of petrochemicals has developed over the last twenty years deriving a wide range of aliphatic and aromatic chemicals from cheap (naphtha) fractions of petroleum. The initial impetus in this field seems to have been derived from the very large scale production of butadiene, styrene and synthetic rubber during the war and has been sustained by the phenomenal post-war development of polythene and other synthetics. It has branched out into a wide variety of chemicals but the processes generally exhibit a high degree of sophistication and being essentially continuous can only be operated economically on quite large scale. For the initial operation a cracker handling of say 200,000 tons of naphtha per annum is usually regarded as fairly small though admittedly crackers of less than half this size have been considered. An integrated complex of many processes is required for the economic utilisation of the many products of such crackers and unfortunately not many of the less developed areas can envisage sufficient demand in the foreseeable future to justify such massive investment.

23. Stripped of its superficial glamour the plastics field is seen to consist of a highly competitive fabricating industry utilising the products of highly developed capital intensive processes. The earlier thermo-setting resins could be produced in relatively simple plant but increasingly stringent specifications demand greater control and complication in the process. The newer plastics are all products of high cost plants and processes. It is proving difficult therefore to produce any of these economically in small units.

24. In the synthetic or artificial fibre field it may not be too difficult to supply local needs of rayon or other cellulose fibre given adequate supplies of cellulose, caustic and other reagents at economic prices, but it must be remembered that the more economic producers operate units of capacity up to 100,000 tons per annum. It is also possible to establish spinning of the true synthetic fibres, polyamide, polyester and acrylics on relatively small scale if importation of polymer or at least advanced intermediates is accepted but complete synthesis will usually demand annual tonnages running into five figures before competitive costs can be approached. All these processes make heavy demands on technically skilled manpower.

25. Reference must be made to the dyestuffs industry which constitutes the main exception to the rule of specialised one-product plants. In view of the literally thousands of dyestuffs and intermediates to be produced much ingenuity is devoted to devising multi-purpose units. Nevertheless, the trend is still evident and most of the primary and many of the intermediate chemicals are now produced by such specialised processes. This is a field in which research and invention play, if possible, a greater part than in any other with a proliferation of patents and constant supplanting of one product or process by a newer one. It is worth noting that no country is entirely self-sufficient in this field and the world situation is confused by the fact that availability even of intermediates varies greatly from time to time according to consumer fashion and level of demand in the various countries. The planning of a dyestuffs unit in a new country is particularly difficult and indeed the economics of producing individual dyes and intermediates are often nearly impossible to asses. In such a field a policy of backwards development is almost inevitable starting with the end product and working back to the primary material as the industry grows. Similar considerations apply also to the multitude of other organic products which have been developed as offshoots of the dyestuffs industry.

26. Reference has already been made to the high cost of modern chemical plants and the influence of the size factor on their economics and been discussed interalia by Chiltern (2), Dickerson (3) and Johnstone (4). It is usual to consider cost as an exponential function of size but the exponent can vary widely and may be as low as 0.5 if the capacity is changed by variation in the unit size of the items of equipment or as high as 0.9 where expansion implies a number of units working in parallel. Neglecting the extreme cases, it is customary to consider the cost of the plant and equipment as varying by about the 0.6th power of the capacity. Such an exponential function obviously implies a serious initial disadvantage in the less developed areas since despite their generally large population, demand even within the next five to ten years will usually be only a fraction o the accepted size elsewhere. It is an interesting observation that in many sectors of the heavy chemical industry the demand in India is of the same order as that in Australia despite the enormous disparity in the respective populations (dyestuffs and soda ash are major exceptions; for obvious reasons)

(2) Chilton, C.H. Chem. Eng. 57 112-114 (April 1950)
(3) Dickerson, R.G. Inst. Chem. Eng. Joint Symposium on Scaling-up (1957)
(4) Johnstone, R.Edgeworth. Trans Inst. Chem. Eng. 32 151-166 (1954)

27. The planner of a heavy chemical unit is therefore often faced with a prospective unit possibly as small as one fifth of the normally accepted size and costing therefore perhaps twice as much per ton-year on account of the scale factor alone. Added to this must of the equipment will be highly specialised and therefore have to be imported involving substantial charges for packing, insurance, freight etc., which may increase the capital cost by, say, a further 25%. In the light of this the levying import duty on imported capital equipment is hard to understand.

28. In addition to this handicap the cost of services plant, laboratories, offices and other ancillaries will generally be much higher pro rata than in the industrially developed regions. In some countries, moreover, it may be necessary to spend perhaps as much as 20% of the total cost of the project on housing and other amenities which elsewhere already exist or are provided independently. All of these factors affect not merely the capital but also the productions costs, as well as the margin of profit required either to service the capital or to justify the projects as already discussed.

29. On the other hand, the other factors affecting production costs are not necessarily so unfavourable. Services may well be obtainable at figures comparable with those in the highly developed countries while the problem of low productivity of local labour has perhaps been over-stressed. No doubt this is being adequately discussed in other sections of the Conference, and it suffices to say that in the author's experience in the heavy chemical industry, quite surprising results have been obtained through the thorough application of work study at the design stage and in "manning-up" together with the fullest training of both supervisory and operating personnel well in advance of starting up new plants.

30. By and large therefore the greatest obstacle to the establishment of the heavy chemical industry in new areas is the increasing sophistication of the processes and the consequent high unit cost of plants which because of the scale factor strongly favours the installation of large units. The mounting bill for heavy chemicals to support general industrial development encourages the establishment of small units at the earliest possible moment but this tendency must be resisted otherwise the prospect must be faced of scrapping them in favour of more economic units at an early date. From consideration of the cost-v-scale factor it is also obvious that economic operation cannot be achieved by the successive installation of uneconomic units operating in parallel. For the same reasons however attractive dispersion of the chemical industry may be politically, fragmentation into uneconomic units can only frustrate the objects of industrial development.

31. The prospect however is not entirely gloomy and in particular the concept of minimum economic size is very arbitrary and depends greatly on local circumstances. It is simply the scale of operation at which an acceptable return or saving is secured with local costs and at obtainable or acceptable price levels. The results of such appraisals may represent

different orders of magnitude in different areas. It is important to realise that in such cases careful re-study of the process from both the technological and chemical engineering aspects will often produce rewarding results. On a smaller scale unit operations can sometimes be combined or the process simplified in other ways. Handling problems are often simplified and where ample low cost labour is available manual handling may even produce substantial savings in both capital and operating costs as well as creating additional employment. It is disturbing at times to see highly expensive equipment installed without any attempt to determine whether its cost is as well justified as in the areas of high cost labour where it was developed. It is always possible to allow for its installation later if and when the increasing standard of living have raised wages to the critical level. In any case climatic conditions and other local conditions such as variations in material specifications and costs usually justify a technological re-assessment or re-interpretation of the process and too much skill and ingenuity cannot be devoted to the problem of reducing capital costs and increasing efficiency. This may also achieve substantial savings in the foreign exchange required to import plant and equipment.

32. Summing up therefore heavy chemicals are the servants of industry generally and the demand for them will grow with increasing industrialisation. As most developing areas are faced with exchange problems the mounting bill will result in pressure to manufacture them locally but since capital is also scarce such manufacture should only be contemplated in well planned units of adequate size. It should also be accepted that integrated manufacturing complexes must be built up to achieve normal efficiencies. Location must be decided strictly on economic considerations having regard to distribution of demand, raw materials, and cost of transport etc., and the timing of projects and their mutual interlocking and support is of prime importance. The marginal gain each year in the struggle towards the so-called "self generating stage" is usually quite small and if political dogma or expediency be allowed to distort sound techno-economic planning the overall objective of industrial and all development will be vitiated. On the other hand, ample technical skill and experience should be devoted to adapting processes and plant to local conditions so as to secure maximum efficiency, reduce capital cost and secure the maximum return on savings.

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THE ROLE OF HEAVY CHEMICALS IN INDUSTRIAL DEVELOPMENT

F. G. LAMONT M.Sc.

SUMMARY

It is widely assumed that the establishment locally of the heavy chemical industry is fundamental to progress from the earliest stages in all the less developed areas. This is not necessarily so (vide Canada, Australia) but in general it will play a large part, though the pattern and impact must depend in major degree on the peculiar circumstances of the area in question. In general development of these areas implies massive capital investment and since the availability of capital, whether from internal savings (private or public) or outside aid is inevitably limited, development must be keenly selective particularly in the early stages. In this the chemical industry must compete with other industries. In such circumstances a considerable degree of planning both central and individual must be envisaged and a sound criterion adopted for the allocation of priorities. Apart from emergency or very special situations the classical assessment of return on total capital involved is still the best yardstick for securing the maximum contribution to progress in the shortest time though unfortunately this criterion will, in many cases, be influenced by the usual necessity to conserve foreign exchange.

Obviously any planning whether on large or small scale must start with an assessment of the area's growing needs against the evolving pattern of its general development. These must be considered against the area's available resources in raw materials, facilities etc., with due regard to geographical distribution.

The major sectors of the heavy chemical industry are discussed against this background. The fermentation industry may have missed an opportunity of developing a field of simpler organic chemicals now being dominated by petrochemicals. Fertilisers may be of early interest. Production of nitrogen products via ammonia are more easily justified than phosphatics. Both lead into the acid industry with which explosives are related but represent a specialised technology.

Chlorine for hygenic purposes can be produced on a small scale but for plastics and general chemistry large units based on low cost salt and power are required. The concurrently produced caustic is usually welcome whereas alkali manufacture via the ammonia-soda process is difficult to justify.

Many organic processes can be operated economically on small scale but this field is increasingly dominated by petrochemicals utilising high cost specialised plants economic on large scale. Plastics generally also involve elaborate high cost plants as does the production of polymers for synthetic fibres though small scale spinning units may be viable based on purchased polymer or advanced intermediates.

The dyestuffs field more than any other uses multi-purpose units though processes for primaries and early intermediates are becoming more specialised. Development in this field should be gradually "backward" from finished dye to primary chemical.

The greatest obstacle to development of the heavy chemical industry in less developed areas is probably its increasing sophistication in the developed countries leading to increasing unit sizes and higher capital cost per ton year. Timing is therefore of the utmost importance so that the economy is not saddled with units of uneconomic size and fragmentation of the industry will largely nullify its benefits. The marginal gain per annum in the struggle to the so-called "self generating stage" is generally small and political expediency or dogma should not be allowed to vitiate should technical and economic planning.

At the same time it should not be assumed that minimum economic sizes established elsewhere are necessarily valid in a new area not indeed that accepted routes or technology are sacrosanct. Indeed the greatest technical effort is required in adopting and simplifying established techniques particularly in scaling down unit sizes to suit local conditions, reduce capital investment and secure maximum return.

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Agenda Item: D.14

Poland

LOW-COST, ONE-FAMILY HOUSING ADAPTED TO LOCAL SOCIAL, ECONOMIC AND TECHNICAL CONDITIONS

By Adam KRZYSZKOWSKI, M.Sc.,
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Poland

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Low-cost, One-Family Housing Adapted to Local Social, Economic and Technical Conditions

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The great extension of urbanization in developing countries makes housing a problem of the key importance.

The present housing shortage makes immediate decisions in this matter imperative, while the extreme disproportion between requirements and the available means and manpower calls for the most careful consideration of the problem and the elaboration of an organisational policy and of its realisation.

The individual character of the structure of towns and settlements in developing countries, quite different from that of the industrialized countries, requires the elaboration of specific individual methods of solution.

These methods should take in consideration the geographical situation of the given country, its climate, traditions and social structure, degree of economic development, and particularly its present sources of material and manpower.

In consequence the realisation of investment programmes should be based on completely new models, individually elaborated for particular countries and specified both from the point of view of physical and technical planning.

1. The expansion-planning of towns in the discussed areas, dating as a rule from second half of the 19th century, was usually nothing but a mechanical transposition of European lay-outs to those territories.

Town planning in the period after the first and even the second world war, generally enhanced these disparities even in the up-to-date planning and architectural systems.

The most difficult problem will be a complex definition of forms of modernization of the regressive and outdated structures of the old urban centres, and of the forms of construction of new towns, or new districts in the developing regions, adequate for new forms of social life.

A proper solution of these problems will be of major importance for the societies in question, and will greatly influence the shaping of new social structures and national mentality.

Even the best examples, taken indiscriminately from industrialised countries, cannot be considered as a basis in these cases.

2. The most difficult problems to be solved will be a proper elaboration of programmes and appropriate town-planning models.

The situation is complicated by the necessity of taking into consideration the present and envisaged living standard and the traditional, but evolving structure of family life.

Our experience in building in the countries of North Africa confirms that it is still in many cases of enormous significance to isolate individual buildings from outside and from each other. It is also important to separate the inner life of the house from visitors /guest rooms/. Thus the arrangement of the rooms and the connection between them arises from this need. The necessity to take these problems into consideration will be more important in Libya, than, for example, in Tunisia, where the evolution of social structural forms has been more developed. In consequence in the building sets in Libya the strict separation from each other, also of the inner courts will be necessary.

Another basic postulate is the necessity for a clear definition of the occupants of these buildings - i.e. the social classes for which the buildings are being erected.

The problem is of the greatest importance as it influences such basic complex factors as:

- the choice of locality for the building estates and the size of lots
- the size of dwellings and their functional design
- the exterior and interior equipment of dwellings and even the technology and methods of realization.

It may be important to gauge the opinions of the future occupants of the buildings, before and after they move in, respecting their views by the use of a questionnaire.

In consequence it will be necessary to take into consideration as widely as possible such problems as:

- the elaboration of programmes and standards for dwellings
- the scope of public-utility buildings and the technical equipment of estates
- the definition of the principles of town planning and architectural systems.

For final and transitional dwelling standards the necessary minimum should be definitely given, both in general and in detail, with particular consideration to the first stage.

Equipment in public-utility buildings demands the reservation of proper areas for buildings which have to be erected simultaneously with the development of the economy and of new social structures, as for instance, creches and nursery schools required by the vocational employment of women. For the same reason the possibility of a gradual extension of such buildings should be considered so as to be in line with the increase in the needs of the population.

Considering the above-mentioned dynamic social changes the introduction of the most adaptable solutions is indispensible.

3. In defining the principles of town planning it should be stressed that considerable economy may be achieved by adopting a proper urban-planning system.

Terrace buildings may be accepted as being the most desirable form of construction in many of the countries with which we are concerned. This applies in particular to the atrium type, which is, in any case, traditional for a number of regions.

The reluctance shown on many occasions to this type of construction arises partly from the tendencies in some countries to abandon the atrium-type building in favour of one-family, detached houses which are considered to be synonymous with social progress.

Nevertheless this system of atrium building, of such long historical traditions, is now being reintroduced in a number of European countries of the highest residential culture, where it is highly valued, for its economy and for the fact that it gives the maximum privacy at low cost. This one-storey building system provides for almost as many occupants per hectare as does the two to three-storey type of detached houses.

Apart from the price of the building site which is greatly reduced with the decrease in area of the plots, the cost of construction of roads and the sanitary equipment of the site will be, in this case, reduced three to five-fold as compared to one-family dispersed housing. At the same time the cost of the buildings themselves will also be greatly reduced due to common walls. In addition there will be a considerable reduction of exploitation costs arising from the higher concentration.

Such apparently rigid aggregate buildings when ideally accommodated to the building site, may give a great variety of composition. This may be achieved by placing individual elements of the aggregate at various heights or the mutual shifting.of the elements at the same level. This will strengthen the deep-seated feeling of "a home of my own" by the concentrated system of building of the individual elements around the inner court. This feeling of "my own home" is most important for societies undergoing urbanization.

The far-reaching adjustment of the structure of the settlements to the topography of the building site will also permit considerable economies in the construction of roads, the development of the area and especially in the layout of green spaces.

Particular emphasis, in this field of site planning, should be placed on the maximum consideration to climatic conditions. Often under-rated it is a factor of great significance in securing proper living conditions.

The information data available here for designers is absolutely insufficient, although it is also of major importance, even at the initial stage of decisions as regards locality. A proper design for an urban lay-out may, for example, secure maximum airiness, even with a great concentration. A building improperly situated in relation to the sun and the prevailing winds can never be properly planned, from an architectural standpoint as regards its protection from excessive heat or lack of airiness.

Irrespective of the building type applied there is no doubt that modern urban building systems should be introduced in gradual stages. The main problems here, as in general are the concentration of building aggregates along green spaces and the proper location, in regard to the latter, of public utility buildings and the elimination of road traffic from the inner area of the estate.

From the necessity to adapt the programme to the existing economic possibilities, there arises the problem of the building of the parts of housing estates, or even of individual buildings in stages.

The starting point would be a nucleus unit consisting of kitchen, sanitary facilities and a living room. Other rooms could then be added gradually, with the advent of requirements and means, up to a full exploitation of the building plot. This proceeding should be forseen in the design in the form of a proper arrangement of individual rooms and other units. For aggregates of buildings such modelling should be applied so that even in the first stages of construction they constitute an entity from the exterior. Further construction would be carried out only from inside around the inner courts. This refers, of course, primarily to the atrium type of building.

Should the construction of whole housing estates be abandoned and substituted by individual private building the latter should also be limited in the number of types foreseen for realisation. At the same time in the plans of housing estates it should be clearly defined on which lots and within what limits the given types should be erected. This would permit the maximum entire realisation, based on the central stocks of building materials and standardised elements. A skilful application of details and colour, and a variety of fencing will, as in the case of whole housing estates, eliminate the monotonous appearance of the aggregates, with its depressing effect on the occupants.

4. In architectural design the trend towards the simplest and lightest constructions is obviously necessary. The building methods applied to multi-storey houses should not be used here. Special simple methods for low-cost, one-family housing, based on local materials, should be applied.

Simultaneously in this type of building, stress should also be laid on standardisation and prefabrication as leading to further economy. This should apply in particular to the standardisation of building sections, construction elements and equipment.

Naturally a prerequisite for industrial production of such elements will be the introduction of a modulus and of a planning grid. This would permit the creation of a base for the industrial production of building elements for stock and the introduction of prefabrication founded on stationary plants for dispersed building or on polygon plants for larger works.

Standard designs must be adapted in their variants to local conditions and the needs of the occupants. The determining factors should be: the size of families; local traditions and customs; climatic conditions; the building materials available in the particular region; the desired standards of finishing and equipment and the working capacities of enterprises.

The vast territories, with their widely-varying conditions, in the countries with which we are concerned, may complicate the problem more than under European conditions. In such a case the most rational solution is one based on repetitive designs

according to the standards accepted for the given housing estate. Such designs must also obviously be based to a maximum degree on standardised construction and equipment elements.

For the construction elements of one-family housing we are primarily concerned to elaborate standards for wall elements, in particular those of pre-fabricated concrete and gypsum, ceiling beams, partition walls and slideable scaffolds for cast walls. Joinery should obviously also be standardised, particularly since, in view of the shortage of timber in many of the countries concerned, and the need for protection against termites, it is necessary to substitute timber by metal. Building standardisation should of course be supplemented as far as possible by a standardisation of equipment. This should be carried out if it is possible to a modest degree; it should primarily apply to the standardisation of kitchen and sanitary installations and wall cupborads.

The need for the maximum adaptability of interior lay-outs to the growth of families and the speedy evolution of social structures has already been emphasised. This gives rise to the possibility of substituting partition walls, where possible by wardrobe sets and shelves.

The great potential for economy in building inherent in this seemingly minor factor of standardisation appears to have been under-rated.

A small flat must, of course, be suitably furnished. The production of modern, light, inexpensive furniture will permit the full exploitation of the new interiors and make possible a further economy in buildings and building sites. This however is a separate problem.

5. There is no doubt that in some countries a shortage of qualified personel makes difficult an analysis of, and the discovery of a solution for all the above-mentioned issues. It would in addition be highly uneconomical.

A solution of the problem requires the introduction of models, derived from comparative analysis and taking into account: geographical situation; climate, national tradition, social structure; the degree of economic development and the resources of manpower and materials. Each country, or region of a country would need to be assigned to a sector determined by the similarities of the above-mentioned factors. Norms based on exhaustive survey of each model would then be elaborated in each sector.

These models would serve the states of the sector with solutions for their problems; they would point to the most economic means and prevent the many errors which are liable to arise by the incidental methods now prevailing.

This work could be undertaken by appropriate international institutes organised with U.N. aid. They would cooperate with each other and, naturally, with the local building institutes of their own country. The latter would be required to provide the basic materials and to make the final adaptation of the proposed models for the individual needs of their country.

Obviously the proposed institutes would not be only technical in character: they would also be required to carry on fair-reach-

ing, demographical, sociological and economic studies.

The results obtained from such an approach might be expected to be of a significant, universal scale. Have we not already witnessed the momentous influence of, for instance, circular huts and light, tropical techniques and the wide-spread acceptance there of spontaneous staniardisation on the ultra-modern designs in countries with the most highly-developed technique.

Under the present system individual designers, particularly in urbanistics, often have to fall back on their own experience since there is usually a lack in a given country of planning organisations or of institutes able to provide comprehensive, analysed, collective and tested data on which to base norms. Control by local administration bodies is usually confined to preventing excessive expenditure and to enforcing the simplest building regulations.

6. . The above-mentioned difficulties, particularly those of manpower and materials, make it imperative to dispose the execution of national housing programmes over a number of stages. We may simplify this by reducing them to two stages:

Stage I - the acceptance of all technological solutions which draw on the local labour market and achieve desired effects with a minimum of imports and the greatest possible restriction of investment means.

At this stage the prevailing trend must be towards training workers, while production is in progress, so that they become at least partly qualified and are able to manipulate the more complicated equipment used during the second stage. They should also be trained in more rhythmic work giving increased production and to show a proper psychological approach to their work.

Simultaneously, at this same stage, great emphasis should be laid on the need for the most expert and the most up-to-date town and architectural planning. At the same time the plans must envisage a continued rise in the standard of equipment, both for whole estates and single structures. There should be maximum use of locally-derived materials, exploited on technological lines, continually brought up to date.

Along with the current work of this stage there sould also be arranged:

- studies and research into methods of work, the technology of construction and the organisation of labour;
- intensive training of the medium and more highly-qualified technical staff
- the establishment of an equipment and material base by the gradual expansion of the production of building materials and equipment and of the plants engaged in this. This applies too to the organisation of prefabrication bases.

Stage II - will depend to a larger extent on the overall economic development of the country, particularly on the existence of an adequate industrial base and on the extension and arrangement of an opposite policy of credit and taxes and on

the adaptation the building administration to the extent of requirements and the establishment of an investment organization

The introduction of modern technological methods at this stage must be preceded by a precise and exhaustive recognition of all contributing factors.

At this stage too there should be a thorough revision and re-application of current building regulations which should be elaborated on the most practical lines with maximum adaptation to the conditions of the country. During this period also standards of area and equipment must also be established in relation to whole urban complexes and to single structures. In addition these norms must also, naturally, leave wide room for adaptation.

It is desirable at this stage to elaborate general plans for all the more important urban centres and to sum up their requirements for housing construction.

7. For the further improving of economic building methods a model of the investment organisation should be elaborated supplementing standardisation, both at town-planning level and for single construction.

It is primarily a question of elaborating a model:
- of the available investment organisation, prepared for the realisation of whole estates,
- of maximum-specialised building enterprises, working on their own resources of stationary prefabricating plants for dispersed building, or of polygon prefabrication plants serving larger works.

The above-mentioned plants may also be directly organised by the state and may serve other branches of building. With their importance their distribution should be considered in great detail and will depend primarily upon sources of raw materials for building, the situation of basic building enterprises and of the proposed building sites.

In many of the countries under our consideration building regulations need to be thoroughly revised since in many cases they are based on outworn patterns, not originally intended for them. They form a considerable hindrance to the development of contemporary building. The new building regulations must naturally also embrace the problems of physical planning as the starting point of any form of building activity.

There is an analogous need to reorganise the building administration service which here is also usually run on lines not adapted to up-to-date needs. Such a revision of the administrative side of building into a modern, pliable organisation will also be of significance in improving residential building, particularly of one-family houses. We have in mind here the provision of aid for individual builders.

The establishment of an industrial base must also be accompanied with the training of higher and medium-qualified technical cadres. Here with the pressing demand and specific conditions of the developing countries there should be the optimum combination of studies with current requirements.

In the organisation of studies it is desirable to exploit the experience of countries which have recently gone through a

building period of a new economy and have achieved significant experience in speedy reconstruction and building expansion. Students engagement in current work facilitates the linking of future cadres with the building traditions of their country.

Higher training should be accompanied by an adequate extension of the training of technicians.

With the great expansion of mass residential building, with its prevailing trend of low-cost, one-family houses, the above-mentioned issues are of key significance.

We are greatly indebted to Mr Władyslaw Podwapinski M.Sc., U.N. low-cost-housing expert in Libya, whom we consulted, with much profit, on the topics of this report.

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ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.14

Poland

LOW-COST, ONE-FAMILY HOUSING ADAPTED TO LOCAL SOCIAL, ECONOMIC AND TECHNICAL CONDITIONS

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Poland

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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Low-cost, One-family Housing Adapted to Local Social, Economic and Technical Conditions

Adam Krzyszkowski, M.Sc., Zbigniew Wolak, M.Sc, Poland

Summary

1. The dynamic growth of urbanistic processes in the developing countries presents housing as a key problem while the glaring disproportion between demand and the resources of manpower and materials calls for the most careful consideration and presentation of organisational policy. The individual structure of towns and settlements in developing countries, quite different from that of industrial countries, requires the elaboration of specific, individual methods of solution.

Methods are primarily determined by: geographical situation; climate; national traditions, social structure, the degree of economic development and above all by available manpower and materials. Thus the execution of investment plans must be based on completely new models of physical and technical planning, elaborated separately for each country.

2. Bearing in mind the basic significance of a solution of these issues for the formation of new social structures there should be maximum emphasis on and a flexible approach to:

- the planning of housing norms and standards
- the determination of the principles on which housing estates are provided with technical services and public utility buildings
- the determination of principles for the physical and architectural planning of aggregates
- in maintaining the traditional but speedily-evolving structure of the family and in providing optimum living conditions for the greatest number of people within the limits of available resources.

Help on these matters may be derived from the use of questionnaires applied before and after taking up residence. In projecting public utility services for housing estates terrain must be reserved for buildings which will be required with the growth and modernisation of social structures.

For these same reasons the possibility must be envisaged in designs of the segmentary extension of structures. For residential buildings the extension could start from the nucleus unit /the kitchen, sanitary installations with a living room/. The premises can then be further extended to the full capacity of the building site.

3. Terrace buildings may be accepted as being the most desirable form of construction in many of the countries with which we are concerned. This applies in particular to the atrium type, which is in any case traditional for a number of regions.

This system has now been reintroduced into a number of European countries and is highly valued for its economy. Simultaneous emphasis must be laid on the introduction of most modern elements

of town-planning both in general and in detail.

4. In architectural design the trend should be towards the simplest and lightest construction while stress should also be laid on standardization, as leading to further economy. This should apply in particular to construction elements and equipment. Naturally a prerequisite for industrial production will be the establishment of a modulus and of a planning grid. Standard designs must be adapted in their variants to local conditions and the needs of the occupants. The vast territories with their widely-varying conditions in the countries with which we are concerned may complicate the problem more than under European conditions. In such a case the most rational solution is based on repetitive designs according to the standards accepted for the given housing estate. The standardisation of construction elements should naturally be accompanied by standardisation of equipment.

5. The analysis of all the above-mentioned issues and the elaboration of a solution for them will meet with much difficulty in some cases for individual countries. A solution of the problem requires the introduction of models derived from comparative analysis of the previously-mentioned factors, and assignment by the similarities of these factors.
These models would serve the states of each sector in obtaining the most economic solution with a minimum of investments. This work could be undertaken by appropriate international institutes.

6. The above-mentioned difficulties make it imperative to dispose the execution of housing plans over a number of stages. We may simplify this by reducing them to two stages:

Stage I - the acceptance of all technological solutions which draw on the local labour market and achieve desired effects with a minimum of imports and the greatest possible restriction of investment means.
At this stage it will be necessary to improve at least to some extent the qualifications of the workers so that they work more efficiently and learn to manipulate more complicated equipment. While carrying out town-planning and architectural design in the most rational manner stress must be laid on the gradual raising of standards, on research into work methods and on the establishment of an equipment and material base.

Stage II - will depend to a greater extent on the overall economic development of the country. The introduction at this stage of modern technological methods must be accompanied by an adapted structure of building administration and the maximum modernisation of building regulations, the establishment of investment organisation and specialised enterprises working on the basis of stationary or polygon prefabrication plants. The overall policy of the training of the higher and medium-qualified technical personnel, with the maximum participation of students in current work must be related to the formation of the industrial base for building.

We are greatly indebted to Mr Władysław Podwapiński M.Sc, U.N. low-cost-housing expert in Libya, whom we consulted, with much profit, on the topics of this report.

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Agenda Item:D.1

Poland

THE CHOICE OF TECHNIQUES IN DEVELOPING COUNTRIES

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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THE CHOICE OF TECHNIQUES IN DEVELOPING COUNTRIES

by Zofia Dobrska PH.D.

The Institute of Economic Sciences of the Polish Academy of Sciences

1. The improvment in living conditions of milions of inhabitants of developing countries depends in the first place on the rate of growth of national income in those countries. This in turn depends on one hand upon the level of investment, i.e. upon the share of accumulation in total income, and on the other - upon the effectiveness of this investment.

2. Since resources at the disposal of developing countries are scarce, the problem of their optimal allocation becomes essential. It consists in selecting the best from the point of view of the countries needs - physical structure of investments and in choosing for separate industries such production techniques, which assure the greatest results from given inputs.

3. The problem of the choice of production techniques concerns in particular the question, whether it is expedient or not to apply in developing countries such production techniques which are used in countries having a high level of development /i.e. highly capital-intensive techniques/.

4. Until the early fifties the prevailing opinion was that in conditions of developing countries which have serious labour surpluses and relevant lack of capital, production technique must differ from techniques used in those countries, which have large capital stocks and relatively few unemployed. In recent years, however, the opposite opinion gains more and more supporters[x]. Before expressing our own opinion we will present in short the state of discussion concerning the subject.

x x x

5. Considering the level of output /P/ in relation to employment, it can be said, that it depends on the ammount of employed /L/ and the labour productivity /W/. Thus the equation is obtained:

$$P = L \cdot W$$

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x. I.a.: H. Leibenstein, W. Galenson, A. Kosen, M. Dobb, and R.H. Bettelheim.

6. This leads to the conclusion that having a certain investment fund we may obtain the increase of production either by employing additional workers having the same labour capacity /that is to say employed in the same traditional technique/, or by increasing the productivity of workers already employed through improving or increasing their equipment, that is to say by introducing a new and more modern technique.

7. Which of those two ways is better, can not be teremined a pri ori, since this depends on how labour productivity will change owing to changes in equipment.

8. Let us assume that a given investment fund would lead - in conditions if traditional technique - to increase employment / and therefore also production / by a certain percent. If the same increase of efficiency ... btained when this fund is used to increase equipment per worker, then from the point of wiew of the level of production the choice of technique is irrelevant. But if the increase of efficiency will be relatively grater, then it will be expedient to invest more intensive techniques and if it will be smaller, than traditional techniques increa... ...ployment should be applied. Of course in every field of production and even in each industry relation between changes of equipment a... changes of efficiency will be different. Simplyfying the question, it can be assumed, that if at the starting point equipment per employed is very low, then its increase will lead to a more than proportional growth of efficiency, after however a certain ceiling of efficiency has been reached, it will grow slower than equipment.

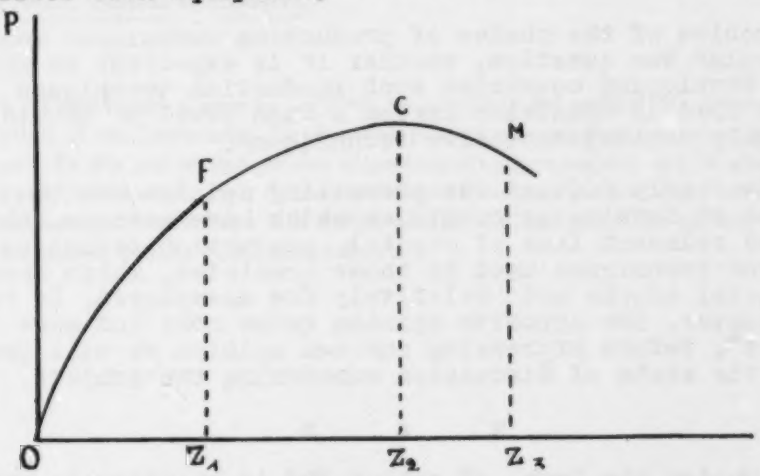

Figure I.
/taken from A.K. Sen's book "Choice of Techniques" Oxford 1960/

9. The problem discused above is shown in Fig.I, where the level of employment has been presented on the horizontal axis and the level of production on the vertical one. Having a definite invest ment fund, a different ammount of workers can be employed, depending on the technique chosen. /Since the total investment fund

is given, the ammount of equipment per worker will be in inverse proportion to the ammount of employed, that is to say, the abciss will present at the same tume the level of employment and the inverse of the intensity of separate techniques. In the same way the vertical axis presenting the level of production obtained from a given investment fund will express the inverse of capital intensity of output attained with separate techniques. If very scarce equipment per worker is used we can employ Z_3 workers, whose output level will be MZ_3. But if we choose modern technique where more equipment per worker is needed, then the productivity of workers [illegible] so that although the ammount of employed will fall to the point Z_2, the total ammount of production will be higher. If techniques still more intensive are used, then though productivity per worker will be increasing, this increase will be slower than the growth of intensity of techniques or else of the fall of employment, so that eventually total produstion will be smaller than before.

10. It is obvious, zhat transition from technique M to technique C is worthwhile in any conditions, because with a given investment outlay and smaller employment, higher output will be reached. What kind of argument, however, could induce investors to use not the technique C but F at which the level of output attained from a given investment fund is smaller? The reason can be only that labour force is too scarce to assure the use of technique C.

11. Those who advocate the use of less intensive techniques in developing countries than in the developed ones, have usually this case in mind. They point out, that in industrialized countries tha lack of labour hands leads to substituting to a large scale capital for labour in spite of the decreasing effectiveness of investment. In less developed countries it is not necessary to use such intensive methods, sonce the labour reserve is sufficient for techniques, which maximise production.

12. Those who are of different opinion do not deny this fact. They stress however, that direct maximisation of output /and also of national income/ can not be an objective in itself, since the planners in developing countries must in the first place take into account the highest possibly rate of longterm economic growth Once this is considered, additional factors come into account, which in their opinion discredit techniques maximising production

13. They point out namely that the choice of production techniques at any given level of real wages determins not only the efficiency of investment but also the share of accumulation in national income.

14. This can be seen on Fig.2, where the line OR is introduced

to show the level of the wage fund. If constant real wages are assumed[x], the line OR will be straight, since the wage level will grow in proportion to the ammount of employed. It can be seen from the Figure, that if technique C is applied, which maximises production, then the wage fund /which in our example is taken as eqiuvalent to social consumption/ will comprise a large part of total output. The size of the investment surplus, that is to say of this part of total production which is left after substracting the share consumed by the workers, will in this case be lower, than when technique F is chosen. Thus there is a contradiction between technique maximising the immediate production and technique maximising the investment surplus, that is to say, assuring the highest long range growth rate of the economy when the initial investment fund is given. This contradiction results of course from the fact, that transition from more capital intensive techniques to less capital intensive ones leads to gradual decrease of efficiency per worker. If the average real wage is kept at a constant level, this efficiency must fall to the point where the ad ditional product produced by a worker will not be equivalent to his real wage. In such a case the total production level will be rising since the worker produces a certain ammount of output/, and simultaneously the surplus will be falling /since he comsumes more than he produces/.

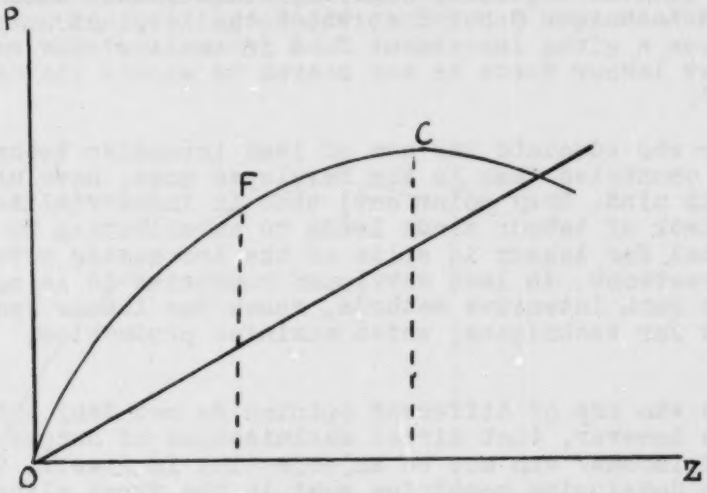

Figure II.
/taken from A.K. Sen's book "Choice of Techniques", Oxford,1960

15. It should be pointed out that the choice between techniques maximising output and techniques maximising the surplus does not

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x. This is a simplified assumption, since as a matter of fact real wages will fall during the transition towards less intensive techniques which however will not change the essential interrelations considered here.

essentially concern private investors. Small, independent producers tend, as a rule, to maximise production, dividing it later in a certain proportion between consumption and investment. A capitalistic entrepreneur will always tend to apply techniques maximising the surplus, since, if he did not so, his profit /which is nothing else but this surplus/ would be smaller. The contradiction presented above can also have no greater practical influence on investment decisions of the planning authorities in developed socialist countries, where full employment has been reached, since in those countries the limitted ammount of free labour force compels to use highly capital intensive techniques, even if those techniques do not maximise production or surplus. But in developing countries, which have a great number of unemployed, where introducing both kinds of techniques is feasible and planning is aimed to a quick rise of social consumption and to assure an adequate rate of growth of national income in the long run, the dilemma, at least from the theoretical point of view, exists.

16. It seems, however, that its importance has been much exaggerated in recent discussions owing to the fact, that a number of elements has not been considered. Those elements on one hand diminish the contradictions mentionned and on the other - they limit seriously the freedom of choice of planning authorities concerning various production techniques. Let us now consider some of those factors.

17. What has been stated above ammounts to saying that each technique of production has a double effect on national income. The direct effect consists of an immediate but single increase of the production capacity and of the production level. Moreover, there is also an indirect long run effect: the technique of production through its influence on income division determines the share of accumulation in national income and to that extent the rate of growth of this income.

18. Techniques aiming at maximising output provide a big direct effect, while their long run effect is small. Techniques maximising the surplus lead to opposite results. Adherents of this second solution argue that slow initial increase of national income, resulting from applying such techniques, is compensated for in relatively short time by a higher rate of growth of income during following years. This is true under the assumptions which they introduce. If the planning authorities have at their disposal a certain investment fund, and if the rate of growth of national income in the following period depends exclusively on the size of the investment surplus resulting from that "initial" fund, then society choosing techniques which maximise the surplus has to restrain from current consumption for a relatively short period of time. A relatively small direct increase of production resulting from that technique is the price which must be paid in the first period. But in all following periods /let us call them "years" assuming that one year elapses starting on an investment project and obtaining its first production effects/, the highest possible rate of growth of national income will be reached/.

That is why in a relatively short time the difference resulting from a lower starting point can be overcome and in the following periods society has at its disposal a higher income, which is growing faster than it would be the case under any other technique. /Thus, if we assume e.g. that the initial investment fund is 1000, and that it provides additional output of 400 if the surplus enables a rate of growth of 2% or additional output of 350 if the surplus enables a rate of growth of 3,5% then the difference of income levels will be balanced already after 9 years if technique maximising the surplus is chosen.

19. Does this mean in fact that technique maximising the surplus always assures the highest rate of growth of the economy as a whole? This was the opinion of those who advocated "surplus maximisation" identyfying tacitly or explicitly the initial investment fund with the total investment fund which is at the disposal of the economy. They assumed, that the investment process starts with the shift of a certain surplus taken from the subsistance sector of the economy, and that the future rate of growth of the economy depends of the economy exclusively on the ammount of resources originating from this initial fund, since the state has no additio nal accumulation funds.

20. This image however is very far from reality[x]. In no country of the world the state development program started from a "tribute" taken once from the population and dependent further exclusively on the "investment surplus" reached from this "tribute". Every modern state has some constant incomes, and a part of those incomes can be each year allocated for accumulation. They come from taxes levied on the population and on private enterprises, domestic or foreign, and especially from "royalties" In those countries, where land reform has been passed, the state takes over a part of the rent previously due to landlords. Finally, it can dispose of incomes coming from state-enterprises which have been either created earlier by the state, or nationalised recently. Income coming from those enterprises is fixed and independent from current investment policies, since it depends upon existing capital equipment of those enterprises.

21. The beginning of public industrialisation consists of allocating a part of those incomes for accumulation. Let us assume that in year 0 the state puts aside a certain part of its incomes, creating thus an "initial investment fund" and allocating this fund to production techniques which maximise the surplus. In the following years a relatively small increase of national income will be reacged, but also there will be a certain surplus coming from investments realised during year 0 which we shall call "the dependent" investment fund. / It is dependent in the sense that

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x. The second part of this paper is based on a large extent on ideas put forth by professor M. Kalecki during his lectures in Spring 1961 at the High School of Planning and Statistics.

its size depends on the choice made by the state in the field of production techniques appied to new investments. But this dependent investment fund is not only fund at the disposal of the state, since contrary to theoretical assumptions on which we have been basing thus far, the state is allocating to investment purposes the same ammount of current budget incomes as before. This part can be called the "independent investment fund", independent in this sense that it is determined externally and its size does not depend on any current investment policy. Will the state assure the highest rate of growth of national economy allocating both those funds to techniques maximising the surplus, as it was the case before?

22. This is not so certain. This technique will assure the highest rate of growth of the part of income which is produced from the "dependent" investment fund, simultaneously however, it will slow down the increase of income obtained from the independent investment fund. As this last fund will be invested in the second year only the direct effect of technique maximising the surplus, namely a small increase of production, will manifest itself. A similar situation will occur in year 3 and it will be repeteade as long as besides the "dependent" investment fund there will be an "independent"one. In other words if we once assume, that the initial investment fund is not a stock but a flow, then it is obvious, that the price, consisting of a small increase of income in the forst period, which under simplyfying assumptions the society had to pay once, must, as a matter of fact, be paid every year, since every year a part of the total investment fund provides a smaller increase of income, than would be the case if it was invested in techniques directly more effective.

23. Those relationships can be presented by the following equation where national income = Y, dependent investment surplus = E, independent investment surplus = K capital output ratio of investment = m /capital output ratio of investments connected with technique maximising the surplus = m_1 and the same connected with technique maximising output = m_2, so that $m_1 > m_2$ /.

$$\frac{\Delta Y}{} = \frac{R}{Y} \cdot \frac{1}{m} + \frac{K}{Y} \cdot \frac{1}{m}$$

24. When the initial investment fund is given only once, then the above equation has only one term, and it is obvious that it will be maximised by m_1 /since m_1 . R give ex definitione the highest rate of growth/. Since m_1 it must be assumed that it is constant flow, the second term of the equation must be taken into consideration and then no answer a priori can be given, whether maximising the rate of growth is connected with technique m_1 or m_2, since the forst one maximises the first, and the second maximises the second expression.

Whether: $\frac{R}{Y} \cdot \frac{1}{m_1} + \frac{K}{Y} \cdot \frac{1}{m_1} \gtrless \frac{R}{Y} \cdot \frac{1}{m_2} + \frac{K}{Y} \cdot \frac{1}{m_2}$

can not be determined as long as the size of K and R and the interrelation between m_1 and m_2 are not known. It is known however, that at the starting point of the state development program R must be small /in the first year it ammounts to 0/ and thus the rate of growth of income will depend in the first place on K, that is to say, it will be the greater, the higher is the immediate efficiency of chosen techniques. As time goes on, the situation will change, since R will rise. /Because every year it will increase by the surplus obtained from K invested in the previous year/. Thus after a certain time it is this figure that will be determing the rate of growth of the whole income.

25. This will happen earlier or later depending i.a. on the origin of K. If the independent investment surplus will be coming from enterprises which were state owned before the investment program has been started, then its overall size will be fixed, and this of course will cause R to exceed K at an earlier moment. But if K will come from taxes levied on the private sector, then its overall size will be increasing together with the growth of national income and thus the moment at which R exceeds K will come later although sooner or later it must come because R increases faster than national income as long as there is an independent surplus.

26. As can be seen, the fact that actually the initial investment fund is not a stock but a flow does not change in an essential way the fact, that in the long run the rate of growth of income will be maximised by techniques which maximise the investment surplus. It introduces, however one essential change into the reasonning, namely that this maximisation of the rate of growth will not start immediately, but only after a certain time, and also that society will have to pay the costs of this policy for a much longer time than was previously assumed.

27. Thus in the example presented before, techniques maximising the surplus will bring results already after nine years. But if we assume that the initial investment fund is not given once, but that it is a flow ammounting every year to 1000, then such results will be reached only after 17 years. If we accept that this flow will be growing together with national income, what is closer to real conditions, the period under consideration would ammount approximately to 2o years.

28. It seems that this change of the time horizon during which positive effects of techniques maximising the surplus will appear can have great significance for economic planning in developing countries. Although the objective of state policy should be to assure long range economic growth, neverthless it is obvious that growth should be visible as quick as possible. Under the present extremely low living standarts in developing countries, it is absolutely impossible, for social reasons, to postpone for a long time the rise of consumption. This can also be impossible for political reasons, since it is easier to induce

the population to accept a program which will begin to yield gains after 10 years, than to obtain its approval of a policy which will bring effects after 20 years, and therefore benefit in principle t the next generation.

29. There is another factor which must be taken into account when the planning authorities decide on production techniques which are necessary from the point of view of the rate of growth of national income, and this is technical progress.

30. Thus far, we have assumed constant techniques: differencies on effectivness, but this effectivness was constant in time, and therefore the share of the investment surplus in national income was also constant as well as the rate of growth of income.

31. In real conditions however technical progress leads to a rise of labour productivity of workers employing a definite technique, and thus total output is rising. Under the assumption of fixed real wages /[illegible]sary when there is serious unemployment/, the wage-fund does not change, and therefore the surplus itself as well as its share in income are rising. This leads to accelerated growth of national income.x

32. Thus the reinvestment of the surplus leads under technical progress /the impact of which can not be omitted in long range planning/ not to a constant, but to a raising rate of growth of national income. Although this does not influence the fact that maximising the surplus is equivalent to maximising the rate of growth / if independent sources of accumulation in the sense determined above are not taken into consideration/ it does however in a sense diminish its practical influence. It is obvious that under those circumstances the planning authorities in underdeveloped countries are not compelled to such an extent to maximise the surplus by introducing capital intensive methods of production. On the other hand the problem of raising employment as well as social consumption as fast as possible becomes more urgent, and this is connected with production methods which are not so capital-intensive.

33. Thus far only total production was considered, under a tacit assumption, that the structure of output /its division between producer and consumer goods/ depends on decisions of the planning authorities which choose some definite technique.

34. Actually, however, the question is not so simple. In some branches of the economy, output can not be shaped at will by the mere level of investment allocated to those branches. In the first place agriculture should be mentionned as such a branch. In less developed countries institutional factors prevailing in agricultur and a low level of technological ~~fx~~ skill among the farmers determin a very stiff ceiling on the growth of output, so that planners must assume that the rate of growth of agricultural production is independent of investment policies, at least in shorter time periods. On the other hand the rise of the wage-fund leads to an

---

x. This acceleration will last as long as there is free labour force.

exceptionally sharp rise of demand for food. The assumption of constant real wages is equivalent in those conditions to the assumption, that the rise of the total wage-fund connected with the rise of employment resulting from the investment program, will not be greater than the increase of the market food supply refered to further as "the food surplus"

35. In those conditions the size of the food surplus will determine the possible intensity of techniques, when the investment fund is given. Intensity of techniques thus determined is not necessarily the same as the one which would be optimal in conditions of complete elasticity of food supply. On the contrary it is very possible, that planners will be forced to choose techniques which are more intensive, than the case of"optimal" choice.

36. Thus the food surplus limiting the growth of employment im developing countries influences decisions concerning the choice of techniques in a similar way, as full employment in highly developed countries. In both cases the rate of growth of employment is usually smaller than the rate of growth of accumulation / it is determined by the "external" rate of growth of the food surplus in underdeveloped countries, and by the "external" rate of growth of the population in developed ones. This leads to the necessity of using intensive techniques, even at the cost of raising the capital output ratio.

37. It should be stressed however, that although the food surplus in developing countries is usually inelastic in relation to investment, this does not mean that it is also inelastic in relation to other means of economic policy, influencing technical and structural limits of agriculture. Certain institutional reforms as well as intensive professional training of farmens may lead to greater elasticity of the food surplus.

38. The above remarks do not of course pretend to be a complete presentation of the problem of choice of "optimal" production techniques in developing countries. They were only aimed at pointing out some aspects of this problem,,omitted sometimes in thepretical discussions which in the authors opinion are of great importance for practical planning. The conclusions are not homogenous. It seems, on the one hand, that in developing countries there is a certain limit of growth of employment which is not very far from the limit determining the choice of techniques in highly developed countries. On the other hand, however, if this limit is not taken into consideration, then production techniques used in highly developed countries do not seem as expedient as they would appear in the light of the arguments of the partisans of the highest technique.

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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.1

Poland

THE CHOICE OF TECHNIQUES IN DEVELOPING COUNTRIES

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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THE CHOICE OF TECHNIQUES IN DEVELOPING COUNTRIES.

by Dr Zofia Dobrska PH.D.

The Institute of Economic Sciences of the Polish Academy of Sciences

SUMMARY

1. In developing economy, with abundant labour supply the planning authorities may choose between two sorts of techniques of production. One is the labour intensive technique, which permits to obtain the greatest immediate output from a given investment fund. The second is a capital intensive technique which gives smaller immediate output, but permits to obtain a larger investment surplus. / As the wage fund forms a smaller part of the overall output, the residual, which can be devoted to investment is greater than in maximizing output techniques./

2. In the traditional economic thinking the emphasis was laid on labour-intensive techniques, as best suited for densly populated underdeveloped countries. In recent years however many economists advocate the use of the capital intensive techniques, arguing that it will maximise the rate of growth of the national economy.

3. The paper emphasises two factors, which can to a great extend limit the usefulness of techniques maximising the investment surplus:

a/ Firstly, the above mentioned techniques maximise the overall rate of growth of the economy only if the "initial accumulation fund" is given once for all. In such a case, the investment surplus obtained from the "initial fund" is the only source of accumulation in the country. The higher it is, the higher is the rate of growth / except for the "first year", when the increase in income is ex definitione smaller than it would be if maximising output techniques would be used/. But actually the planning authorities have also at their disposal a more or less stable "flow of income" /from taxes etc./, a part of which can every year be used for accumulation. If in this circumstances the planning authorities decide to use maximising surplus techniques the loss of the part of national income, which in the preceding case occured once / in the "first year"/ will occur year by year - because year by year the invested part of the "flow of income" will bring an increase in national o income smaller than it would be under maximising output techniques. As at the beginning of every development programe the share of the "flow" in the total accumulation fund of the economy will be much grater than the share of the "investment surplus", the negative effect of the maximising surplus policy will be more important than its

favourable effect. The overall rate of growth of the economy can thus be - during quite a long period - smaller, than if the maximising output techniques were to be used.

b/ The second factor taken into account is the effect of the technical progress on the size of the investment surplus. As technical progress leads - ceteris paribus - to the enlargement ot this surplus and therefore to the acceleration of the rate of growth of national income, the problem of "maximising the surplus" becomes less acute and more attention can be paid to the problem of employment.

4. Athough the theoretical arguments of the partisans of "maximising" the surplus" techniques are not always sound, the planning authorities may be forced by the inadequate food supply to limit the opportunity for new employment and thus to choose rather intensive techniques of production.

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Agenda Item: D.5.1

Sweden

SOME ASPECTS ON THE TREATMENT OF SPENT LIQUORS FROM THE CELLULOSE INDUSTRIES IN ORDER TO REDUCE POLLUTION

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Some Aspects on the Treatment of Spent Liquors from the Cellulose Industries in Order to Reduce Pollution.

By Rolf Brännland, Mo och Domsjö AB, Örnsköldsvik, Sweden.

1. Pollution effect of pulp mill effluents

In the cellulose industries various kinds of wood are treated in order to separate the cellulose fibers from other constituents of the wood. The main pulping processes are the Kraft (sulfate), the acid sulfite and the neutral sulfite processes. Since the content of cellulose is relatively low, cf. Table 1, about half of the organic matter will remain in the spent liquors from these processes.

Much work has been done to make use of the spent liquors, e.g. for production of ethyl alcohol (1), fodder yeast (1), vanillin (1), and acetic acid (2). However, only a minor part of the organic material can be removed by such processes.

Table 1. Constituents of spruce wood according to Hägglund

cellulose	41.0 %
hemicellulose	26.7 %
lignin	28.6 %
miscellaneous (resin, ash etc)	3.7 %

In may cases the spent liquors are sent directly from pulp washing to sewage, hence polluting lakes and rivers, i.a. by consuming oxygen dissolved in the water when being biologically degraded.

The pollution effect is often measured as the biological oxygen demand (BOD) during a 5 day test (3). The BOD of various types of effluents from pulp washing and bleaching was reported by Bialkowsky and Brown (4), cf. Table 2.

Table 2. BOD of various pulp mill effluents

type of liquor	kg BOD per ton pulp	remarks
acid sulfite	300 - 380	pulp washing
neutral sulfite	120 - 130	
Kraft (sulfate)	390 - 550	
paper sulfite	13 - 17	pulp bleaching
dissolving sulfite	57 - 60	
Kraft (sulfate)	9 - 20	

The values from Table 2 indicate that the untreated waste liquors from a 100,000 ton per year mill (bleached acid sulfite) would cause a BOD of about 100 ton per day. Since the normal BOD of domestic sewages is about 75 g per person and day (3), the pollution equivalent of the pulp mill mentioned would be a city with about 1,300,000 inhabitants. The figures indicate that, in many cases, measures must be taken either to reach sufficiently large recipients, e.g. by building long

sewage pipes, or to decrease the pollution load, e.g. by recovering certain constituents of the spent liquors or by burning them. However, before burning, the spent liquors must be evaporated. Recent investigations (5) show that the BOD of these condensates can not be neglected, cf. Table 3.

Table 3. BOD of various condensates from spent liquor evaporation

type of condensate	kg BOD per m^3	kg BOD per ton pulp
acid sulfite	3 - 10[a]	20 - 60
neutralized acid sulfite	2 - 4	10 - 20
Kraft (sulfate)	1 - 2	6 - 8

a) Lower values apply to soft wood, higher ones to hard wood.

By evaporating and burning, the BOD load can be decreased by 70 - 90 %, depending on the efficiency of the pulp washing. It is, however, necessary to make these processes economically attractive, and this is achieved by recovery of heat and chemicals.

The effective heat value of spent acid sulfite liquors, evaporated to 55 % solids, is about 2000 kcal per kg (6), corresponding to a net saving 2 - 3 Gcal or $3 - 5 per ton pulp. Kraft liquors have somewhat lower, and neutral sulfite liquors considerably lower heat values.

Recovery of chemicals has been applied in Kraft mills for many years, but now the growing use of "soluble" bases, i.e. magnesium, ammonium, and sodium in sulfite mills has necessitated recovery of chemicals also in this branch of the cellulose industry. Table 4 gives an approximate idea of costs for chemicals, if no recovery is applied.

Table 4. Approximate costs for chemicals with various sulfite bases

chemical	$ per ton chemical	$ per ton pulp
CaO (as $CaCO_3$)	10	0.6 - 0.8
MgO (as $MgSO_4$)[b]	30[a]	1.4 - 1.6
NH_3	100	3.6 - 4.4
Na_2O (as NaOH)	75	5.0 - 6.0
Na_2O (as Na_2SO_4)[b]	35[a]	2.4 - 2.9
S	30	3.0 - 3.6

a) corrected for sulfur content
b) possible only in connection with chemical recovery

When burning sulfur containing liquors, one must be aware of the risk of transforming water pollution into air pollution. Flue gases from sulfite liquors may contain up to 0.5 % sulfur dioxide (7), and gases from Kraft liquors up to 0.05 % hydrogen sulfide and mercaptans. Methods of decreasing the air pollution will be briefly discussed below.

2. Treatment of Kraft liquors

In the Kraft process a solution of sodium hydroxide and sulfide is used as the pulping liquor, and hence recovery of the base is necessary. Since the recovery process is well-known and thoroughly described in the literature, it will be only briefly discussed.

The black liquor is separated from the pulp in a system of either filter washers or diffusers, cf. Figure I. A liquor recovery of 95 % may be reached without difficulty. In multi-stage vacuum evaporators the solution is then concentrated from 14 - 20 % to 55 - 60 % solids. In order to fix malodorous volatile sulfur compounds, the black liquor may either be oxidized in a special tower, or the tail gases scrubbed with alkali.

The thick liquor is finally burnt in specially designed boilers. In some cases the flue gases are utilized for final direct evaporation of black liquor. This method seems, however, to cause unnecessary stripping of hydrogen sulfide by the carbon dioxide content of the flue gases. Electric precipitators are normally used for recovery of solids (sodium sulfate) from the gas, and sometimes heat is also recovered in scrubbers of various types.

The green liquor, formed by dissolving the melt from the boiler, is regenerated by clarification, recausticizing with lime, and clarification of the resulting white liquor, which is used for pulping. Nowadays the calcium carbonate sludge is burnt in rotating kilns and reused for causticizing. In this way chemicals are saved and a waste problem solved.

The efficiency of regeneration is 90 - 95 % in the Kraft process, which gives a comparatively low BOD of effluents, i.e. 50 - 70 kg BOD per ton pulp. However, blow gases from digesters and flue gases from boilers contain small percentages of odorous sulfur compounds. Much effort has been taken to eliminate emission to the surroundings, but as yet there seems to be no perfect solution to the problem.

3. Treatment of calcium sulfite liquors

Calcium is the classical base in sulfite pulping, primarily owing to its low price. In most cases, cooking acid is prepared by contacting water, lime stone, and sulfur dioxide in a reaction tower. Recovery of the base has not been regarded as economical, cf. Table 4, but sulfur recovery has been discussed (7).

The spent liquor is very often sent directly to sewage, but is sometimes spread on gravel roads as an anti-dust chemical. References have already been given to processes for utilizing various compounds in the liquors (1, 2).

During the second world war methods were developed for evaporating and burning the liquors, thus recovering heat and decreasing water pollution. The spent liquor is separated from the pulp in a combined blow pit and washing tank. With respect to the lower value of the chemicals, the efficienty is comparatively poor, 75 - 85 %. The solution is then evaporated from 10 - 15 to about 55 % solids in multistage evaporators of either vacuum or back-pressure type. In this case acid resistant steel must be used in heat exchangers, expansion vessels, etc. Another cost increasing factor is the scaling of calcium sulfate, which necessitates arrangements for channel switching or other cleaning (e.g. condensate washing) of heating surfaces (6).

The calcium sulfite thick liquor is then burnt in a boiler, which must be specially equipped, e.g. with a Loddby furnace, in order to facilitate the ignition of the liquor. The inorganic residue is taken up in cyclones as ash, containing mainly calcium sulfate, oxide and carbonate. It is normally wasted, but in some cases it is used for neutralizing sulfite liquor prior to fermentation.

The BOD of effluents from a sulfite mill using spent liquor burning may reach 60 - 180 kg per ton pulp, depending on the efficiency of pulp washing, type of pulp etc. The flue gas from calcium liquor burning holds 0.3 - 0.5 % sulfur

dioxide and some fly ash. No injuries to surrounding vegetation have been reported so far.

4. Treatment of magnesium sulfite liquors

Magnesium has met a renaissance as base in sulfite pulping in the last ten years. As a metter of fact, the first Swedish sulfite mill started with magnesium in 1874, but then changed over to calcium. Now the interest bas been directed towards magnesium in the search for bases with higher solubility than calcium (magnesium permits operation at pH up to 5.5 - 6.0). Several new sulfite mills have been equipped for magnesium pulping, e.g. Cosmopolis (Wash., USA), started in 1957, Sitka (Alaska, USA) in 1960, and Nymölla (Sweden) in 1962.

Table 4 shows that magnesium salts are rather cheap, and the base is in some cases used without recovery of chemicals (e.g. at Wausau, Wisc., USA, and Hunsfos, Norway). Normally the magnesium mills are, however, equipped with recovery units operating according to the flow sheet in Figure II.

The cooking acid is prepared by dissolving sulfur dioxide in a slurry of magnesium oxide (8). The recovered spent liquor is evaporated just as calcium liquor, and burnt in a specially designed boiler. In this case the inorganic substance is almost completely dissociated into sulfur dioxide and magnesium oxide. The ash is first collected in cyclones, and then washed with water to a slurry, which is used for absorption of sulfur dioxide from the flue gases in a tray of absorption towers.

5. Treatment of ammonium sulfite liquors

Ammonium is a soluble base, which is easy to handle but rather expensive, cf. Table 4. In some old mills it is used instead of calcium in order to increase the pulping capacity or give a higher degree of freedom in the choice of pulp wood (e.g. at Lebanon, Ore., USA, and Toten, Norway). However, economical recovery of the base is not possible; only sulfur may be reclaimed.

After separation from the pulp, the spent liquor is evaporated and burnt. During evaporation a tendency to formation of condensation products has been observed, sometimes interfering with the operation and necessetating cleaning with nitric acid. The boiler normally operates very smoothly, since only gaseous products are formed: the inorganic compounds are oxidized to nitrogen oxide and sulfur dioxide.

6. Treatment of sodium sulfite liquors

Many processes have been suggested for the recovery of the sodium base. The reason is that sodium gives a total freedom in choosing pH of pulping, but is too expensive for being used without recovery, cf. Table 4. In several cases "cross recovery" has been applied, i.e. fresh chemicals are added to the sulfite mill, and the spent liquors transferred to a neighbouring Kraft mill. The draw-back is that the sulfite capacity may reach only a certain fraction of the Kraft capacity.

Among the separate recovery systems, the Stora Kopparberg process (8) is in widest use (Skutskär and Domsjö, Sweden, and Nova Scotia, Canada). The features of this system are shown in Figure III. The recovered spent liquor is concentrated in acid resistant evaporators and burnt in a special boiler equipped with electric precipitators to collect ash. The inorganic chemicals are obtained as

a melt of sodium sulfide (75 %) and carbonate, which is dissolved and clarified. The solution is then carbonated, and the sulfur content stripped off as hydrogen sulfide, which is contacted with sulfur dioxide in a Claus reactor and transformed to elemental sulfur.

The bicarbonate solution is mixed with bisulfite under formation of carbon dioxide and sulfite, which is used for sulfur dioxide absorption and cooking liquor preparation. In the sulfur system the roast gases are washed first with water used for preparation of liquid sulfur dioxide, and then with sulfite solution. Finally the flue gases, containing 0.3 - 0.4 % sulfur dioxide, are also scrubbed with sulfite solution. The Stora process may seem rather complicated, but since only liquid and gaseous streams are handled, the operation is smooth.

The Sivola process (8) is practiced at Rauma (Finland) and its principal features are much the same as in the Stora process. The clarified green liquor is, however, partly carbonated with carbon dioxide from flue gases. Bicarbonate crystals are then separated on a filter and used for preparatic of sulfite-bisulfite solution for the first cooking stage. The mother liquor is utilized in a third cooking stage, which is typical to the process. Liquid sulfur dioxide for the second stage is prepared by stripping cooking liquors and by condensing the gas, at high pressure.

Another process using a Kraft boiler and sulfide recirculation is the Western-Precipitation process (8), tested i.a. at Nekoosa (Wisc., USA).

Recent investigations have shown that it is theoretically possible to direct the combustion of spent sodium liquor so that a solid phase of carbonate is obtained, and the sulfur is completely volatilized as sulfur dioxide. This process is under development in Canada (Gauvin's AST-process) (8) and Sweden. Since an entirely new technique must be applied, many problems concerning materials of construction, temperature control, etc. have to be solved before the process can be utilized on a full scale.

7. Treatment of neutral sulfite semi-chemical liquors

Also in semi-chemical pulping "cross recovery" has been applied in several cases. Since cooking liquors of lower purity can be accepted, recovery systems have been developed, which are less complicated than in the acid sulfite process.

In the Mead recovery process (8), used i.a. at Watervliet (Mich., USA), carbon dioxide from flue gases are utilized for the whole green liquor carbonation and therefore a comparatively high thiosulfate content is obtained. The solution is then sulfited with sulfur dioxide in the flue gases and used as pulping liquor.

The Zimmermann process (8), employed by Borregaard in Norway, is based on wet combustion of the spent liquors, cf. Figure IV. These are first neutralized with carbonate and then oxidized with air at 200-300°C and 50-200 atm. A turbine operated by expanding gases, is used for the air compression. The sodium sulfate is finally converted to carbonate by barium salts circulating in the system, and sulfited by sulfur dioxide from the barium cycle.

8. BOD development at a Swedish pulp mill

The effect of various measures to decrease pollution is illustrated by Figure V, showing the development of BOD of wasted liquors at a Swedish sulfite mill. The BOD was first decreased to about 75 % by removing sugar from the liquor by

fermentation, then to about 35 % by evaporating and burning the calcium sulfite liquor. Finally the improved pulp washing connected with switching over to sodium base further decreased the output so that the BOD is presently not higher than in 1932.

Air pollution increased when the liquor burning started, then decreased at the base switching, and will be practically eliminated by a flue gas scrubber, which will be in operation in 1963.

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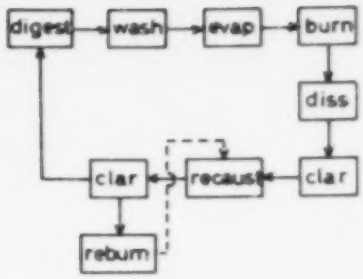

Figure I. The Kraft process.

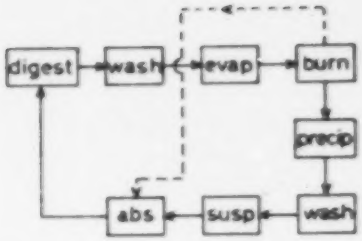

Figure II. The Mg sulfite process.

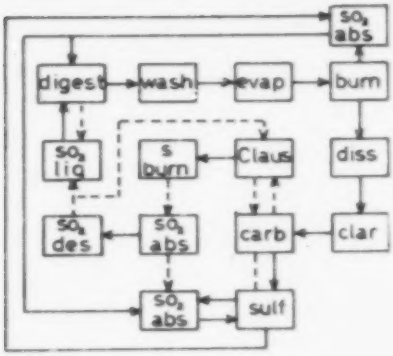

Figure III. The Stora process.

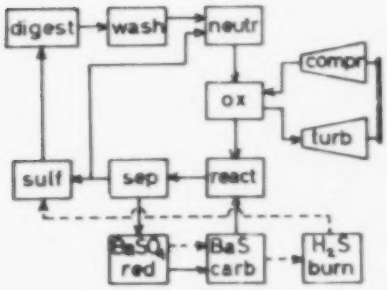

Figure IV. The Zimmermann process.

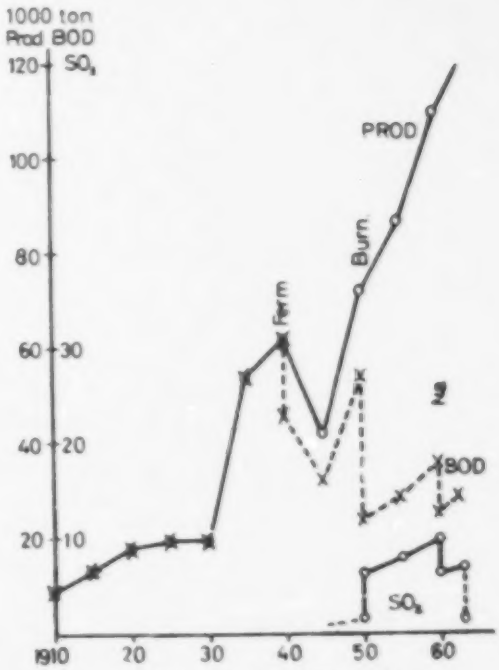

Figure V BOD at a Swedish mill.

Page 7 of paper no 2099 (Item D.5.1.), "Some Aspects or the Treatment of Spent Liquors from the Cellulose Industries in Order to Reduce Pollution" by Rolf Brännland, Mo och Domsjö AB, Örnsköldsvik, Sweden.

587 E - Oct.1962 - 1,600

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SUMMARY
10 Oct.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.5.1

Sweden

SOME ASPECTS ON THE TREATMENT OF SPENT LIQUORS FROM THE CELLULOSE INDUSTRIES IN ORDER TO REDUCE POLLUTION

By Rolf BRÄNNLAND,
Mo och Domsjö AB,
Örnsköldsvik, Sweden

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for the Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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Some Aspects on the Treatment of Spent Liquors from the Cellulose Industries in Order to Reduce Pollution.

By Rolf Brännland, Mo och Domsjö AB, Örnsköldsvik, Sweden.

SUMMARY

Many cellulose industries are vexed with severe pollution problems owing to the low content of useful material in the wood. It has been shown that a production of 100,000 tons of bleached sulfite pulp may cause a BOD of wastes equivalent to a city of 1,300,000 inhabitants.

The obvious advantages of using soluble bases have, however, accelerated the development of processes for recovery of chemicals and heat from spent pulping liquors. Simultaneously the possibilities of reducing pollution have increased greatly.

In the Kraft process the recovery technique is well established and the BOD of effluents from such a mill is low, i.e. 50-70 kg BOD per ton pulp. On the other hand there seems to be no perfect solution as yet to the air pollution problem.

The acid sulfite recovery processes have been developed mostly in the last 20 years. Evaporating and burning spent sulfite liquors is now technically feasible, and by these operations the BOD of effluents may be reduced to 60-80 kg per ton pulp, depending on efficiency of pulp washing, type of pulp, etc.

Recovery of calcium and ammonium is not regarded as economical, whereas magnesium is presently recovered in several mills but wasted in some. Sodium is used only in a few mills, and necessarily recovered. The Stora, Sivola, Western-Precipitation, and Gauvin processes are described.

In semi-chemical mills, using neutral sodium sulfite, "cross-recovery" with a neighbouring Kraft mill is often practiced. The recovery is complicated by the low heat value of the spent liquors, but facilitated by the lower demand for purity of cooking liquors. The Mead and Zimmermann processes are described. The BOD of effluents from a semi-chemical mill with recovery may reach 30-40 kg per ton pulp.

Finally an example is given of the BOD development at a Swedish sulfite mill; fermentation gave a reduction to about 75 %, burning to about 35 %, and switching to sodium base to about 30 %.

The most important recovery processes are represented by flow sheets, and references are given to more detailed descriptions in the literature.

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ORIGINAL : ESPAÑOL

CONFERENCIA DE LAS NACIONES UNIDAS
SOBRE LA APLICACION DE LA CIENCIA Y LA TECNOLOGIA
EN BENEFICIO DE LAS REGIONES MENOS DESARROLLADAS

Punto del programa : D.13

Venezuela

PROGRAMA DE INVESTIGACION DE ARCILLAS INDUSTRIALES DE VENEZUELA COMO EJEMPLO DE ESTUDIO Y EVALUACION DE LOS RECURSOS MINERALES

Por Dr. Federico RIVERO P.,
Director del Instituto Venezolano
de Investigaciones Tecnológicas
e Industriales

Las monografías presentadas en la Conferencia de las Naciones Unidas sobre la Aplicación de la Ciencia y la Tecnología en Beneficio de las Regiones Menos Desarrolladas constituyen documentos de trabajo de dicha Conferencia. Se publican tal como han sido presentadadas por los colaboradores y los puntos de vista expresados en ellos corresponden a los colaboradores. (Véanse notas al dorso.)

NOTAS

1. Las monografías seleccionadas para las Sesiones Generales serán distribuidas en la Conferencia en los siguientes idiomas oficiales de las Naciones Unidas: español, francés, inglés y ruso.

2. Las monografías seleccionadas para las Sesiones Especiales serán distribuidas en la Conferencia únicamente en uno de los idiomas oficiales antes indicados.

3. Los resúmenes de las monografías presentadas por los colaboradores serán distribuidos en la Conferencia en los siguientes idiomas oficiales de las Naciones Unidas: español, francés, inglés y ruso.

4. No se procederá a la distribución general de las monografías y resúmenes con antelación a la Conferencia. Unicamente serán publicadas en cantidades limitadas con antelación a la Conferencia para uso exclusivo de las delegaciones de los gobiernos participantes y de otros participantes autorizados. La publicación con posterioridad a la Conferencia y la distribución general de las actas y debates de la Conferencia seguirán las prácticas de las Naciones Unidas establecidas por la Junta de Publicaciones de las Naciones Unidas.

PROGRAMA DE INVESTIGACION DE ARCILLAS INDUSTRIALES DE VENEZUELA COMO EJEMPLO DE ESTUDIO Y EVALUACION DE LOS RECURSOS MINERALES

por Dr. Federico RIVERO P.
Director del Instituto Venezolano de Investigaciones Tecnológicas e Industriales

PREMISAS:

1° Ha sido considerado fundamental para el logro del bienestar mundial de los paises en vías de desarrollo, la obtención de una estable y sana evolución industrial.-

2° Se considera que, consustanciado con la evolución industrial, es básico el conocimiento sistemático y científico de los recursos naturales de que disponen los países. Este conocimiento debe incluir en el campo de los recursos minerales desde la magnitud de los yacimientos y facilidades y métodos de explotación, hasta la investigación de campos de aplicación, costos de refinación y normalización, así como también costos y procesos de industrialización.-

3° Dada la magnitud de la labor a realizar y la general escasez de recursos disponibles, se ha considerado fundamental un estudio con miras a legir los recursos a investigar. Dicho estudio consta de: A) Importancia económica dentro y fuera del país del recurso natural que se piensa investigar. B) Industrias existentes y de posible establecimiento, que puedan consumirlo. C) Capacidad científica y económica para llevar a cabo la investigación.-

Las premisas anteriores sirvieron de base para que el Instituto Venezolano de Investigaciones Tecnológicas e Industriales (INVESTI), institución privada y sin fines de lucro, proyectara y presupuestara un programa de investigación sobre Arcillas Industriales. El programa comenzó a principio de 1961 y se piensa concluir en 1963, cubriendo el total del territorio venezolano, que tiene aproximadamente un millon de Km2. Hasta el presente se ha realizado el reconocimiento de más del 35% del país, recolectándose más de 650 muestras, y se trabaja en su tipificación y estudio.-

Por sonsiderar que el enfoque dado a este programa de investigación, así como su organización y desarrollo pueden ser útiles a los países en estado de evolución, nos hemos permitido presentar su descripción en este trabajo.-

I) IMPORTANCIA DEL RECURSO.-

El conocimiento de los recursos minerales tanto como para un país en desarrollo, como para los de alta evolución, es de gran significación económica, ya que a demás de ser un posible material de exportación, puede ser utilizado en planeamiento de una evolución industrial que abarque, desde el refinamiento del mineral bruto, hasta el establecimiento de industrias basadas en su utilización.-

La importancia relativa de los recursos minerales, varía de un país a otro. En Venezuela los minerales combustible (Petróleo) tienen una gran preponderancia sobre los restantes. Sin embargo esta posición actual no implica que los otros recursos minerales metálicos y no metálicos, no tengan una gran importancia potencial, y en este aspecto, no solo los ya medidos y en franco proceso de explotación e industrialización, como hierro, sino otros que, como los minerales no metálicos, nunca han sidos seriamente estudiados.-

Tratando de medir este factor potencial, hemos considerado útil las estadísticas de los EE.UU., por considerar que ese país ha logrado un alto grado de conocimientos y consiguiente utilización de los recursos minerales. El gráfico que presentamos, copiados de los datos estadísticos dados por el "Minerals Year Book" (publicado por el Dpto. del Interior de los EE.UU.) presenta la evolución de estos recursos desde el año 1925 al año 1954.-

Estas estadísticas muestran para el año 1954 la importancia relativa de las explotaciones de recursos minerales de EE.UU. así:

Minerales combustibles	$ 9.909.000.000
Minerales no metálicos (con exepción de combustible)	2.617.000.000
Minerales metálicos	1.506.000.000

La importancia de los minerales no metálicos es evidente, y dentro de ellos, las mismas estadísticas nos dan la relación en $ para el mismo año de 1954, así:

Cemento	$ 763.413.017
Piedra	" 602.037.290
Arena y Grava	" 496.671.727
Sulfuros	" 142.014.215
Arcillas	" 123.165.420

Las arcillas ocupan por lo tanto, el quinto lugar en valor en la producción de minerales no metálicos de los EE.UU.-

La importación de arcillas para el mismo año por los EE.UU. es de solo:

Natural	$ 2.445.000
Manufacturada	" 40.000

Es decir, apenas un 2% de la producción del país.-

Es interesante considerar el caso de un país en franca expansión industrial, como México. Los datos estadísticos muestran el valor de la importación de arcillas así:

	1956	1957	1958
Pesos Mexicanos:	19.157.986	21.753.402	25.528.196

Este incremento anual notable en valor importado de arcillas está aparejado al desarrollo industrial de México, lo cual se expresa en un trabajo publicado por el Instituto Mexicano de Investigaciones Tecnológicas (IMIT).

"El país importa anualmente considerables tonelajes de diversos tipos de arcillas, los cuales iran en aumento de acuerdo con las necesidades industriales, y que solo podran ser disminuido cuando el país produzca mediante una tecnología apropiada, arcillas comparables en calidad y constancia de especificaciones, como las que distinguen a las arcillas de importación".-

La importancia de las arcillas en la industrialización de un país, mostrada con los ejemplos de EE.UU. y México, requiere aún la comprobación en el campo nacional para poder justificar la programación de una investigación. Venezuela deriva sus ingresos principalmente de la explotación petrolera y es lógico iniciar en esta industria la búsqueda del posible uso de la arcilla; así nos encontramos que la perforación de pozos requiere el empleo de lodos especiales para los cuales son necesarias arcillas del tipo bentonítico. Además las refinerías de petróleo utilizan arcillas decolorantes, denominadas Tierras de Fuller, y ciertas sub-bentonitas activadas. Desde luego la industria petrolera requiere la utilización de material refractario, y en el proceso de refinación por cracking, arcillas catalíticas. La naciente en industria siderúrgica requiere el empleo de grandes cantidades de arcillas para las matrices de fundición y refractarios. Cemento, caucho, insecticidas, papel, pinturas, son industrias establecidas y en franco desarrollo en el país, todas las cuales usan arcillas de distintas características. La industria cerámica en los ramos de la producción de sanitarios, refractarios y azulejos de encuentra en desarrollo bastante avanzado y la impor-

TACIÓN DE ESTOS PRODUCTOS SE HA SOMETIDO A LICENCIA PREVIA.-

La revisión final del recurso nos ha mostrado que nacional o internacionalmente, las arcillas tienen una gran importancia; que a medida que se logra una intensificación del desarrollo industrial se presentan un incremento del uso de las arcillas; que el desarrollo industrial obliga a producir arcillas refinadas que permitan ofrecer a las diversas industrias productors de especificaciones rígidas, y que ligado a ellos, está el hecho de que el país pueda o no suplir con su materia prima las necesidades de su propia industria. Todo esto obliga no solo a una exploración del mineral, sino a una investigación tecnológica que permita determinar los tratamientos adecuados y los costos de producción de mineral refinado a las especificaciones requeridas por las diversas industrias que lo consuman.-

2) REQUERIMIENTOS PARA EFECTUAR LA INVESTIGACION.-

La investigación se basa en la siguiente planificación:

a) Recopilación bibliográfica sobre la materia.-
b) Labor de geología económica en el campo.-
c) Trabajo de laboratorio para la determinación de características físicas químicas de las muestras.-
d) Contacto con la industria establecida para conocer sus requerimientos y características de las arcillas que utilizan.-
e) Inventario de los usos industriales de las arcillas para estudiar la posibilidad de establecer nuevas industrias de acuerdo a las arcillas que se encontrasen.-
f) Estudios técnico-económicos, mediante plantas pilotos, de costos de refinación y normalización de los diferentes tipos de arcillas, de acuerdo a los requerimientos de las diferentes industrias y comparación en calidad y precios con los productos importados.-
g) Estudios técnico-económicos, mediante plantas pilotos, de nuevas industrias en base a los tipos de arcillas encontradas.-
h) Contacto con los centros internacionales de estudio de arcillas a fin de adquirir conocimientos científicos y técnicos, así como mantenerse al tanto de los adelantos sobre la materia.-

En la realización de dicho plan, ya en avanzada ejecución hemos comenzado a cumplir los diferentes puntos así:

1) Se hizo previamente, en vista a los requerimientos, una determinación de la calidad y cuantía del equipo humano necesario, así como del material de trabajo.-

2) Se estructuró una metodología y se elaboró un programa en cuanto a tiempo y zonas así como tambien se hizo el cálculo del presupuestón necesario.-

3) En un país como Venezuela, cercano al millón de Km2. la realización de una investigación de tal naturaleza requiere la adopción de métodos de análisis de producción en serie.-

4) La organización de un programa de esta magnitud, requiere una cuantiosa inversión en equipos de laboratorio y entrenamiento de personal. Fué por lo tanto necesario considerar detenidamente la posibilidad de utilización de equiposy conocimientos adquiridos en otras investigaciones. Era por lo tanto necesario visualizar al comienzo, la extensión del programa en otros campos afines, en los cuales equipo y personal pudiesen aprovecharse con eficacia. A este respecto se encontró conveniente estimar el programa como una iniciación dentro de una división del Instituto, consagrado a la investigación de los recursos minerales de Venezuela, con énfasis en minerales no metálicos en su etapa inicial.-

5) Una vez superadas estas etapas se hacía necesario lograr el financiamiento del programa; para ello decidimos "vender la idea". Así, con nuestro proyecto de investigación, acudimos a los Institutos oficiales y privados, y aunque no logramos obtener los Bs. 300.000.00 del presupuesto calculado para el primer año, nos hemos esforzado y realizado durante dicho año (1961) el estudio del programa y la realización de la exploración de la zona nor-occidental del país, En lo que va transcurrido del 2º año del proyecto (1962), los programas de campo y laboratorio se han acelerado y se organizan actualmente 2 plantas pilotos, una para refinación y otra para la produc

CIÓN DE ARCILLAS EXPANDIDAS Y DENSAS, CON PROPÓSITO DE ENCONTRAR UN SUSTITUTO DE AGREGADOS PÉTREOS.-

6) En vista de los trabajos efectuados y resultados obtenidos hasta el momento, la forma de ejecución de tan extenso programa ha sido estudiado intensamente y se ha dividido en los siguientes pasos básicos:

OBJETIVOS INMEDIATOS:

La investigación de los depósitos de arcilla en Venezuela y la determinación de sus usos industriales.-

OBJETIVOS A MEDIANO PLAZO:

El logro del autoabastecimiento de los requerimientos de arcillas del país, así como la posible exportación de material natural o refinado y el establecimiento de nuevas industrias en vista a las arcillas encontradas.-

OBJETIVOS A LARGO PLAZO:

La creación de una división dentro del Instituto, capaz de llevar acabo la - investigación sistemática de los recursos minerales del país.-

O R I E N T A C I O N:

El programa se extiende desde la exploración de los yacimientos de materia - prima sobfe el terreno mismo, hasta la cooperación con la industria interesada existente, y el fomento de nuevas industrias dentro del vásto campo de las arcillas industriales.-

7) La prospección preliminar de depósito de arcillas se efectúa en forma sistemática por un geólogo de larga experiencia en el país, el cual recoge todos los datos geológicos disponibles sobre las zonas a investigar. Esto se ha logrado gracias a la colaboración del MINISTERIO DE MINAS E HIDROCARBUROS, así como las Compañías CREOLE - SHELL y MENE GRANDE. Con la información disponible, el geólogo recorre todas las carreteras y caminos de la zona en estudio, ubicando en los planos aquellos yacimientos encontrados por simple inspección visual que presenten posibilidades industriales; - se recogen muestras representativas numeradas y que se remiten al Instituto, efectuando simultaneamente una estimación tentativa del volumen explotable del depósito.-

8) Las muestras al llegar al laboratorio se mometen a una serie de ensayos mineralógicos, químicos, físicos y cerámicos, que constituyen la "marcha nalitica" y que permiten clasificar las arcillas desde un punto de vista de utilización industrial.-

La posibilidad de llevar acabo sobre todas y cada unas de las muestras que - llegan al laboratorio la totalidad de los ensayos, no solo resulta antieconómico, sino también en muchos casos, inútil.-

Después de un estudio con 300 muestras sobre las cuales se llevaron acabo - todos los ensayos de una manera rutinaria, se ha llegado a establecer un sistema de pruebas eliminatorias dentro de los distintos campos de utilización de las arcillas. Este sistema de eliminación es lo que propiamente se denomina "marcha analítica". El cuadro que se anexa da una explicación del funcionamiento de la "marcha".-

Como se puede observar, además de la prospección de campo y de la preparación de las muestras, el trabajo rutinario se reduce a 10 pruebas y las que se sigan por resultados promisores..-

9) Economía de explotación: Las arcillas de uso industrial promisor son estudiadas nuevamente con objeto de determinar las impurezas que contienen, la manera más económica de eliminarlas, las características y la extensión del depósito, su posibilidad de explotación y vías de acceso, costos de transporte, etc. todo lo cual permite hacer una estimación económica del yacimiento.-

10) Plantas Piloto: A la investigación preliminar de una posibilidad favorable de explotación económica sigue un estudio de "Planta Piloto" que compruebe las conclusiones de tal investigación.-

11) Colaboración con la Industria: Este paso del programa, evidentemente de importancia esencial, tiene a su vez tres fases: cooperación con la industria en marcha..

COLABORACIÓN ESTRECHA CON LA INDUSTRIA EN FORMACIÓN; PROMOCIÓN DE AQUELLAS INDUSTRIAS NO EXISTENTES SOBRE LAS CUALES EL ESTUDIO PRELIMINAR DE PLANTA PILOTO HAYA INDICADO - COMO ECONÓMICAMENTE VIABLES.-

12) ESTUDIO DEL AUTOABASTECIMIENTO: A BASE DEL CONTACTO ÍNTIMO CON LA INDUSTRIA EXISTENTE Y SUS NECESIDADES DE MATERIA PRIMA, DETERMINAR LA POSIBILIDAD DE SATISFACER LA DEMANDA INTERNA MEDIANTE EL ESTABLECIMIENTO DE PLANTAS DE REFINACIÓN DE ARCILLAS Y POR LA LOCALIZACIÓN DE YACIMIENTOS DE ALTA CALIDAD.-

13) EXPORTACIÓN: ESTUDIO DE LA POSIBILIDAD ECONÓMICA DE EXPORTACIÓN DE MATERIAS PRIMAS, AL NATURAL O REFINADAS.-

14) CONTACTO CON TODOS LOS CENTROS DE ESTUDIOS DE ARCILLAS A FIN DE MANTENERSE AL TANTO DE LOS ADELANTOS CIENTÍFICOS Y TÉCNICOS AL RESPECTO.-

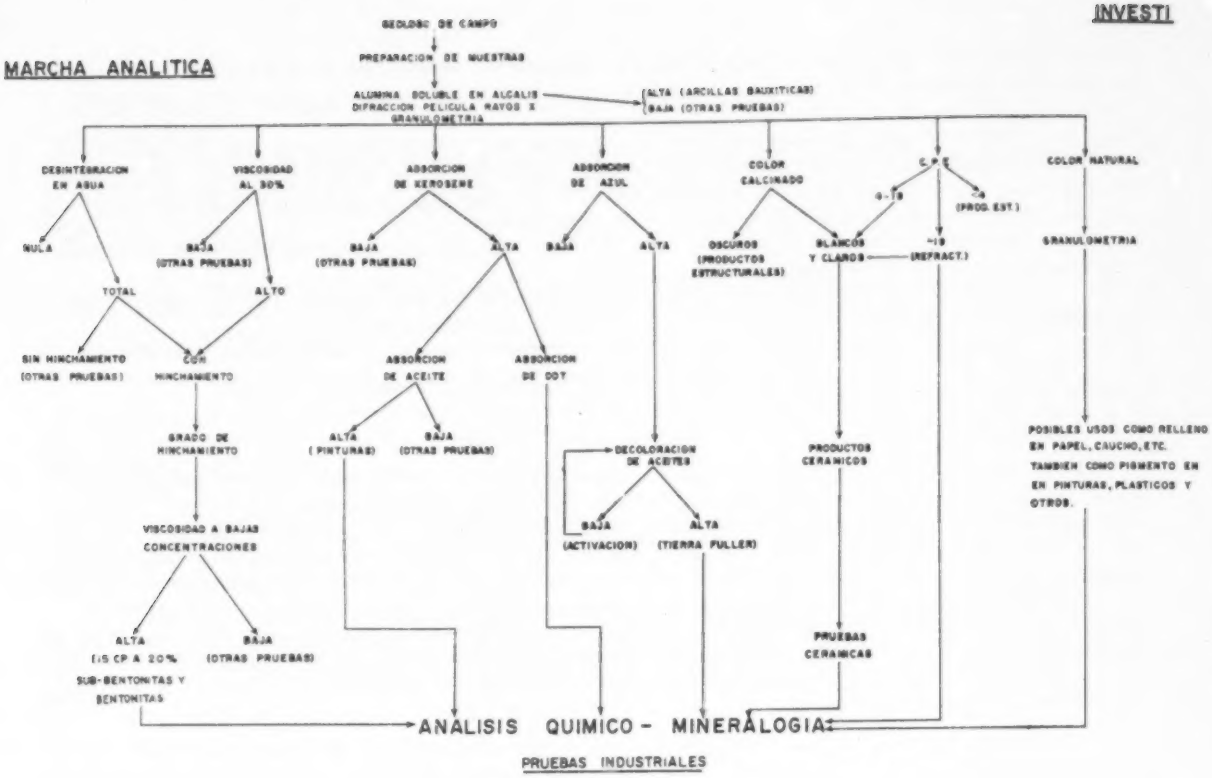
15) PREPARACIÓN Y ORIENTACIÓN DE LOS RECURSOS HUMANOS Y MATERIALES ACUMULADOS - EN EL PROGRAMA DE ARCILLAS PARA SU FUTURA UTILIZACIÓN EN LA INVESTIGACIÓN DE OTROS RECURSOS MINERALES.-

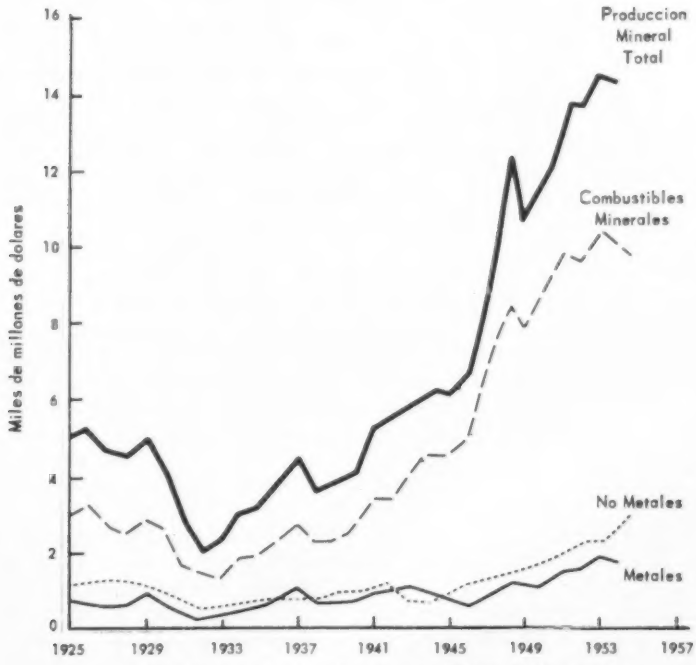
C O M P L E M E N T O.-

COMO FRUTO DE LA EXPERIENCIA ALCANZADA EN EL DESARROLLO DEL PROGRAMA Y DEL MATERIAL BIBLIOGRÁFICO RECOPILADO, ASÍ COMO DE LA COLABORACIÓN QUE A NUESTRO INSTITUTO HAN BRINDADO GENEROSAMENTE ORGANIZACIONES NACIONALES Y EXTRANJERAS, HEMOS PUBLICADO UN FOLLETO QUE CONTIENE LAS "BASES TÉCNICAS' DEL PROGRAMA. ESTA PUBLICACIÓN ES LA - PRIMERA DE UNA SERIE EN REFERENCIAS AL PROGRAMA QUE SE DEDICARÁN A DESCRIBIR Y CATALOGAR POR REGIONES, LAS ARCILLAS DE UTILIZACIÓN INDUSTRIAL DE VENEZUELA. CONSIDERAMOS QUE LA PRIMERA PUBLICACIÓN, ES DECIR, LAS "BASES TÉCNICAS", POR SU CARACTER GENERAL - PUEDE SER ÚTIL A CUALQUIER PAÍS EN DESARROLLO, QUE ENCUENTRE CONVENIENTE EMPRENDER UNA INVESTIGACIÓN SIMILAR, Y ES POR ELLO QUE ANEXAMOS A LA PRESENTE MONOGRAFÍA EJEMPLARES DE DICHA PUBLICACIÓN.-

FRP/CH.-

MARCHA ANALITICA





Valor de la produccion mineral en los EE.UU. (1925 - 1954)

Tomado del "Minerals Yearbook 1954" - Tomo I - PG. 55 -

879 S - Oct.1962 - 600

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ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.13

Venezuela

RESEARCH PROGRAM ON INDUSTRIAL CLAYS OF VENEZUELA AS AN EXAMPLE OF STUDY AND EVALUATION OF MINERAL RESOURCES

By Dr. Federico RIVERO P.
Director of the Institute Venezolano
de Investigaciones Tecnológicas
e Industriales (INVESTI)

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No. 1557
D.13

RESEARCH PROGRAM ON INDUSTRIAL CLAYS OF VENEZUELA AS AN EXAMPLE OF STUDY AND EVALUATION OF MINERAL RESOURCES.

By Dr. Federico Rivero P.
Director of the Instituto Venezolano de Investigaciones Tecnológicas e Industriales (INVESTI)

SUMMARY

1º) Premises: It is considered necessary for the evolution of industry in a country the knowledge about its mineral resourses and it is recommended, before starting out a research program, a careful study of the following points:

a) Economic importance of the resourse.
b) Actual and future industries which may consume it.
c) Detailed discrimination of the work the investigation may require and determination of the scientific capacity and economic possibilities to carry it out.

2) An aplication of these recommendations was carried out in the program "Arcillas Industriales".

3) Data is presented in order to prove the importance of clays for industrial purposes.

4) The possibility of using clay resourses in Venezuela is reviewed.

5) Organization of the program.

6) Budget: The budget was obtained by "selling the idea" to different government and private organizations.

7) Organization:

a) Prospection: A field geologist with all information available at hand, takes the samples and makes a visual volume estimate of the deposit.

b) "Marcha Analítica": Samples are run through a series of eliminating type of tests, which indicate the possible industrial use without undue work.

c) Samples which appear promisory in these first tests are further analyzed.

d) Pilot Plant: Clays which could be definitely used in industry are run through a pilot plant to determine cost of standarization.

e) Cooperation with existing industry as well as promoting new industries in the field of clays.

f) Close contact with international clay research centers.

g) Study of possible diversification of equipment and "know-how" invested in this program for other investigations.

h) Complement: A copy of "Bases Técnicas" is enclosed. This publication describes the technical work which is done on "Industrial Clays"

S - 879 E - Oct.1962 - 1,600